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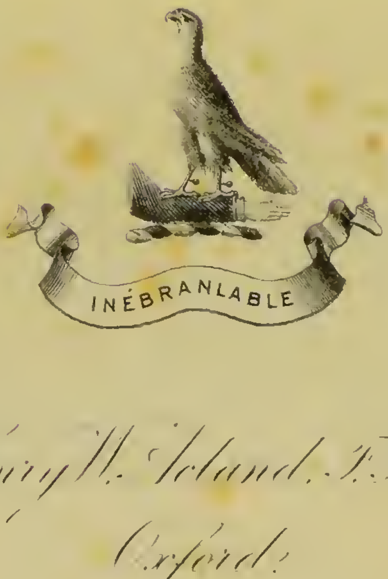

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REPORT

ON THE CHIEF

RESULTS OBTAINED BY THE USE

OF

THE MICROSCOPE,

IN THE STUDY OF

HUMAN ANATOMY AND PHYSIOLOGY;

BY JAMES PAGET,
DEMONSTRATOR OF MORBID ANATOMY AT ST. BARTHOLOMEW'S HOSPITAL, &c.

LONDON:
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PREFACE.

The design of the present Report, of which the greater part has been already extensively circulated in the British and Foreign Medical Review for July last, is to bring together, in the briefest possible space, the principal conclusions regarding the structure and the functions of the several tissues of the human body which have been rendered certain or most probable by microscopic investigation. The task will, it is hoped, be deemed worthy of the labour which has been bestowed upon it; for in no department of medical science has there been so great an addition of facts in the last ten years as in minute anatomy; and in none has the access to knowledge been more difficult. The greater part of the original records of microscopic anatomy are scattered through a multitude of monographs, brief dissertations, and essays in the foreign journals, to which few can refer; and in our own language there is no work which affords an adequate notion of their contents. In France, Holland, and Italy there is the same defect; and even in Germany it existed till, very recently, the systems of general anatomy of Henle,[1] and Bruns[2] appeared.

The writer has endeavoured to keep within the strict limits of the office he has assumed; he has rarely done more than report what has been already published; but that he might report it accurately and impartially he has been careful to draw his materials from none but their original sources.

Some of the numerous reference notes may seem superfluous; but they are inserted in the belief that with their aid it will not be difficult for any one who has access to the works quoted to fill up the outline of knowledge which the text affords. By the aid of some, interesting histories of discovery may be traced; by others, facts may be found which, though they now seem unimportant and are, for brevity's sake, omitted, may hereafter become valuable; by means of others again, the description of the structure of particular organs, and the details of the facts which are related in general terms in the text, may be at once referred to.

October, 1842.

[1] Allgemeine Anatomie, von J. Henle—Leipzig, 1841, being the 6th volume of the new German edition of Sömmering's Anatomie. The Report was nearly completed when this admirable work arrived in England: but the numerous references made to it will sufficiently prove of how much avail it has been for addition and confirmation to what had been written.

[2] Lehrbuch der allgemeinen Anatomie des Menschen, von Victor Bruns.—Braunschweig, 1841. 8vo.

REPORT, &c.

The fact of the one origin of all the tissues from primary cells suggests that the most natural arrangement of them must be that in which they are placed in a succession corresponding to the degrees and modes in which, in their perfect condition, they severally retain or deviate from the primary form. And although, from the imperfection of the knowledge hitherto attained, such an arrangement cannot yet be certainly and completely established, there are sufficient advantages in even a partial adoption of it to warrant its employment on the present occasion, with only such modifications as the physiological relations of certain parts seem, in some instances, to render more convenient than a strict adherence to system.

DEVELOPMENT OF CELLS.

The discovery of the laws of development of and through cells, the greatest achievement of the microscope, is due to Schleiden[1] and Schwann[2]. The former determined it in the vegetable, the latter in the animal, tissues. Hypotheses of cellular development, which in some respects came very near the truth, had been formed by Heusinger,[3] Raspail,[4] and Dutrochet;[5] and several of the facts of the structure of cells had been discerned by Robert Brown, Purkinje, Valentin, and others; but the facts and their explanation had never been combined till the time of Schleiden and Schwann. Since the publication of their works, many facts have been adduced which show that the law, though its general truth is confirmed, must, at least in its application to animal development, be modified; but the changes to be introduced are as yet so uncertain, that, for present use, it seems best to adopt the original system, and merely to append to it the facts by which it may hereafter be altered.[6]

A Primary Cell, or as it is sometimes called, a nucleated or elementary cell, is a minute vesicle, usually of a spheroidal or oval form, composed of a fine transparent membrane, containing an albuminous, gelatinous, oily, granular, or other fluid, and having on its wall, or in its interior, a small body called the nucleus or cytoblast, which, again, commonly contains one or more dark round spots, nucleoli, or corpuscles. Such cells are found either persistently or temporarily, as one of the forms passed through in their development, in all, or nearly all, organized tissues, whether animal or vegetable, normal or morbid. Whatever be the tissue to be developed, the first periods of its development seem to be similar. There is not first developed for each structure a peculiar form; nor is each produced first on a small scale and then enlarged: but in all, the molecules are first arranged according to similar laws; and the nucleated cell is the form up to which in every tissue the principle of development seems to tend, and from which it proceeds in a different direction for the further development of each.

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[1] Beitrage zur Phytogenesis.—Müller's Archiv, 1838.

[2] Mikroskopische Untersuchungen über die Uebereinstimmung in der Struktur und dem Wachsthum der Thiere und Pflanzen. Berlin, 1839.

There is an excellent analysis of these two works in the British and Foreign Medical Review, vol. ix.

[3] System der Histologie, 1828.

[4] Nouv. Syst. de Chimie organique.

[5] Mem. pour servir à l'Histoire .... des Vegetaux et des Animaux, 1837.

[6] The best accounts of these later investigations are given by Henle, in his General Anatomy, and by Reichert in the Jahresbericht of Müller's Archiv for 1841, which is chiefly devoted to criticism of Henle's observations.

The material in which the cells are formed, and from which they derive their means of increase, is a structureless fluid or soft substance, and is named cytoblastema. In the embryo it is that which has been called the formative, or primary, or indifferent substance: in the perfect animal it is the nutritive material effused from the blood-vessels into the interstices of already-existing tissues. When cells are formed and fixed in it, it is usually called intercellular substance, and may undergo changes which contribute much to the character of the fully-developed tissue.

In the development of all organized bodies, then, there may be traced the development of primary cells; and in that of some, the further development of various forms from or through such cells.

The development of the cell is attained in different methods, but the chief of them may be reduced to two schemes. The first is that which is general in plants, and which Schwann believed to be as common in the animal tissues. In it there are first produced in the cytoblastema minute granules, perhaps simple cells. Around each one or more of these, an imperfect layer of substance gradually collects by a sort of coagulation of part of the cytoblastema, and this becomes gradually more dense till it forms a fine membrane around the primary granule. The membrane continues to grow, and increases more in superficial extent than in thickness; so that after a time, a space is left between its inner surface and the granule. The space is usually filled with fluid, and the granule remains attached to some part of the membrane. In the next place, a second membrane forms upon the first, and, enlarging at a much greater rate than the first does, separates from it, appearing at first "like a watch-glass upon a watch," and then gradually rising and leaving a cavity which receives a fluid within it. Thus there is produced a membranous cell, inclosing or bearing on its wall a second much smaller cell, which again incloses, or bears on its wall, one or more granules or cells. The largest and last-formed is the *primary cell:* the next the *nucleus:* the third and smallest the *nucleolus.*

The other scheme of development, which is probably the most frequent in the animal tissues, differs chiefly in the mode of formation of the nucleus. This is not developed as a cell upon a granule, but, of the granules which are first formed in the cytoblastema, a few (rarely more than three) collect, adhere together, and compose a nucleus, in which one granule larger than the rest seems sometimes to compose a nucleolus. On a nucleus thus formed, the cell developes itself in the manner already described; and, as the cell is developed, the granular character of the nucleus diminishes. The granules, which at first adhered very loosely, become inseparably united; and then, as if by the collection of all their solid material to their common circumference, they are gradually changed to a minute smoothly-walled vesicle filled with fluid.

A scheme nearly analogous to this is observed in the globules of the first milk, and in some globules of pus and of inflammatory exudations, and several morbid products; in which a great number of granules collect together, and tend, or attain, to the formation of a cell without any distinct nucleus. As in the preceding, the nucleus was formed without a distinct or previous nucleolus, so here, the development proceeds immediately by the aggregation of many similar granules to the formation of the cell.

In whichever of these methods they be produced, the primary cells seem to possess the power of working upon their contents, upon each other, and upon the intercellular substance, and of effecting those diverse chemical and structural changes by which the infinite variety of organized tissues is produced. According

to these changes Schwann divides all the elementary forms of animal structures into five chief divisions, as follows:—

In the first, the form of the primary cells is nearly retained, and they either float separately in a fluid, or are moveable on each other. Of this division are the blood-, lymph-, mucus-, and pus-corpuscles, and the endogenous cells of certain glands, which, in their completest state, are primary cells floating in a fluid, and in which the changes after the formation of the cell are limited to those of their size and form, and those of their contents, in which, colouring and other matters, or new cells, are generated.

In the second division, the primary cells are distinct, but they cohere by their walls, and sometimes firmly enough to form a connected tissue, as in the several varieties of cuticle, in pigment-membranes, and in fat. The changes of form which some of the cells in this class of tissues undergo, though greater than those of the preceding class, are simple. They assume a flattened, or an elongated, pyramidal, or conical form; they throw out processes which become ciliæ, or which, in some cases perhaps, as in certain pigment-cells, form canals of communication between the adjacent cells; or they are merely changed in form by their mutual pressure, which makes them angular, as in the epidermis-cells. Their contents also may be changed—becoming transparent, or having granules formed in them, or disappearing and permitting the cell to dry.

In the first class, the fluid in which the cells float may be regarded as a permanent cytoblastema: in the second, the cytoblastema seems to be entirely or nearly consumed in the formation of cells; in some only of the tissues, a small quantity of it remains as a structureless intercellular substance, holding the cells together. In the third class, it becomes an important constituent of the tissue. The cells are nearly persistent in their primary form, but are separated from each other by the cytoblastema, which constitutes the chief mass of the tissue, and with which the walls of the cells are ultimately fused. Of this class are the bones and cartilages, of which the peculiar corpuscles are the primary cells, and the basis or intercellular substance in which they lie is the former cytoblastema. The chief differences in the cartilages depend on the relative quantity of the intercellular substance, and on its acquiring in its later development a finely fibrous structure. The canals of the bone-corpuscles either grow out from the sides of the cells, or are produced by spaces (intercellular passages) being left in the material deposited within the cells in the later period of their development.

The fourth class is composed of tissues which in their adult state consist of fibres; the cells in which they originated having undergone an entire change in their appearance. In these, among which the chief examples are the varieties of fibro-cellular tissue, each primary cell becomes elongated and spindle-shaped, and its extremities are drawn out into fibres. These fibres sometimes branch, and, at the last, they break up by splitting from the end towards the centre, where the several fissures meet, and form a bundle of fine filaments or tubules. In this way it is believed that from each primary cell a fasciculus of the filaments of fibro-cellular tissue is produced.

The fifth and last class in Schwann's arrangement comprises the tissues which are formed from cells whose cavities, as well as their walls, have become connected together. In some of these the cells arrange themselves in rows, each being fixed to the ends of the two next to it; and the partitions which are at first formed by their apposed extremities being absorbed, the cavities of all the cells gradually merge into one. Thus, in the place of a row of primary cells, there is formed a single long cell, a secondary cell, whose wall is composed of the side walls of a series of primary cells. Such are the nerve-fibre, the muscular fibre, and the tubules of glands which have simple membranous walls. The secondary cell may grow like a primary cell, and may form various substances in its interior; the peculiar nerve substance, and the muscular fibrils, are supposed by Schwann to be deposited within the cavities of such secondary cells;

and the seminal corpuscles, and the corpuscles of several other glands, may be placed in the same list of secondary intra-cellular formations.

In another case belonging to this division, the cells, instead of arranging themselves in rows and coalescing end to end, lie scattered at some distance from each other, and, sending out processes from their sides into the surrounding cytoblastema, assume the shape of radiating cavities. Their processes coalescing, they become a network of canals, in which the differences of caliber, which at first existed, are gradually annulled. In this way, it is believed, the capillary blood-vessels are formed.

Such was Schwann's system. Some facts are now to be mentioned, according to which it must be in a measure modified. In it the nucleus is supposed to take no important part, except in being the necessary precedent of the cell; when the adult state of the cell is attained, the nucleus is supposed to be absorbed, as it probably is, in most instances, in the vegetable tissues. But it seems more probable, that in the production of many animal tissues, the nucleus has a more important part to perform. In Dr. Barry's system (examples of which will be noticed in their places), the nucleus has a greater share in development than the cell. Henle also states that the persistence and further development of the nucleus are frequent, and enumerates as the only parts in which it disappears, the blood-corpuscles, the cells of the epidermis and nails, and most of the fat cells, the tubules of the lens and enamel, the bone-, and some of the cartilage-corpuscles, and the gland-tubules. But in all fibres that are formed, as he believes, from fused or coalesced cells (with the exceptions of those of the lens and enamel), the nuclei remain and undergo remarkable changes. Especially, they are often elongated into thin narrow corpuscles, resembling fine dark striæ, which lie upon the exterior of the cell-fibres (that is, the fibres which are formed by the metamorphoses of cells, or which stand in the relation of cells to the nuclei), in straight, angular, tortuous, or spiral lines. After being thus changed they may be nearly absorbed; but more often they are further developed, and send out filaments by which they connect themselves into continuous fibres called *nucleus-fibres.*

Henle describes two principal types according to which in these cases the nucleus-fibres are arranged. When the cell-fibres are cylindriform, as those of the fibro-cellular tissue, they have the nuclei on their borders; when they are flattened, as the organic muscular fibres, the nuclei lie on their flat surfaces. In the former case the nuclei may lie in a row on one side only, and as they elongate and are united, they form a band along one border of the fibre; or they may lie in rows alternately on two opposite sides, and each may grow towards that on the opposite side which is at the next level above it, so as to form, when all have met, a spiral coil around the cell-fibre. In the latter case, that is, when the nuclei lie on the surface of a flattened cell-fibre, they have a tendency to send off lateral branches, and thus to connect themselves into a net-work over the surface of each layer of the fibres.

The formation of the flattened fibres just spoken of is peculiar, and seems to be an example of a class of changes in development, which were not mentioned by Schwann; those namely, which are effected through the medium of a layer or sheet of structureless membrane. In the development of the coats of blood-vessels, for example, layer after layer of cytoblastema in the form of structureless membrane, is deposited; and in each of these layers, nuclei are formed, which become the seats of several different changes. Cells may form in the ordinary manner upon them, as in the development of the epithelium of blood-vessels; or they may remain with little alteration, as in the inner membrane of blood-vessels; or, as in the formation of nucleus-fibres already described, they may elongate and arrange themselves in rows. In the last case, which occurs in the organic muscular fibres as well as in those of the contractile arterial coat, each row of nuclei appropriates, as it were, the adjacent strip of the

homogeneous membrane, which thus breaks up into flat fibres, each bearing the row of nuclei after which it was modelled on its side or surface. Lastly, these rows of nuclei may, in either of the two ways already described, elongate, send out filaments, and coalesce into straight, spiral, or reticular nucleus-fibres upon the surface of the flat fibres.

The structureless membrane may be produced at once as a kind of cytoblastema; but in certain cases it seems to result from the coalescence of a layer of cells, as in that which is called the fenestrated arterial coat, and in the sheath of the roots of the hair, as well as, according to Reichert, in the layers of the cortical substance of the hair. In these cases also, another peculiar metamorphosis of the membrane is shown. Cells in a single layer having first united by their margins, and formed a membrane, this, when the nuclei have been absorbed, and the cells are completely fused, becomes simple and homogeneous. Such a membrane is usually stiff and brittle. Granules may now be deposited on it, and arrange themselves in rows, so as to form filaments which have a longitudinal direction, or compose a network, and lastly, the membrane is gradually absorbed in the spaces between the filaments, and they alone remain forming a system of fibres. Or, without such deposits of granules, definite portions of the membrane are absorbed, and a perforated or fenestrated membrane remains; or, the absorption goes on so far as to leave behind only flat fibres in fasciculi, or in a network.

With the aid of this sketch of the development of the elementary forms of the animal tissues, the plan here followed will be plain, and the few words said of the development of each tissue will probably be sufficiently intelligible.

From what has been said, it is plain that the process of nutrition is something very different from that commonly described as the result of the *action* of the blood-vessels. Tissues are not laid down as such, but each forms itself out of a similar structureless material, and none attains its perfect form without passing through several of the stages of development just described, over which blood-vessels seem to have no other influence than that of being, in certain cases, the conveyers of material. In the embryo, before blood exists or has been sent to any part, each part receives or consists of a similar material, which, by a power implanted in it according to a plan specially ordained for each creature, works itself into the peculiar form of each part. And when once a tissue is fully developed, the act of its nutrition is still the same. Each tissue abstracts from the blood, or otherwise receives, a similar material in the quantity necessary for its repair or growth, and this material, as in the embryonic state, developes itself. Only now its tendency to assume this or that form is influenced by the tissue adjacent to it; for, with its perfect development, each tissue seems to acquire a peculiar power of assimilation, that is, of determining another adjacent substance capable of development to assume the same form and composition which itself has.

In the degeneration of tissues also, or in that which may be called their involution, as the contrary of their evolution or development, and which is preparatory to their removal from the body, they cannot be considered as *taken* up, or absorbed, without change, by absorbent or other vessels. They probably retrograde through part of the stages through which they passed in their development, return to their former structureless or fluid state, and then mix with the fluid which is passing into the circulation for excretion, or for the nutriment of other parts.

I. BLOOD-CORPUSCLES.

The discovery of the blood-corpuscles by Malpighi[1] was one of the first fruits of microscopic study, and since that event few objects have been more solicitously examined. It is now agreed that they are minute, flattened, transparent cells, containing (at least during one period of their existence) round or oval nuclei, and having incorporated in them all the red colouring matter of the blood.

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[1] Athanasius Kircher, Malpighi, and John Swammerdam have all received from different writers the honour of this discovery. Whoever will, may satisfy himself of the

a. Form and size. They are circular in man and in all mammalia, except the camel tribe in which they are elliptical;[1] and they are elliptical in all other vertebrata, except certain cyclostomes in which they are circular.[2] In all, they are flattened and have rounded borders. Whether their surfaces be slightly concave or convex depends on variations in the quantity of their contents which may ensue either within, or after their removal from, the body. In invertebrata they are less numerous but more varied in form; for the most part they are irregular, granular, roundish, nucleated corpuscles.[3]

It is difficult to discern any strict connexion between the various sizes of these bodies and the other parts of the organism of different animals. Among mammalia those of the elephant are the largest;[4] then come those of the capybara and rhinoceros;[5] then those of man, which have an average diameter of about $\frac{1}{3500}$ or $\frac{1}{4000}$ of an inch.[6] In general those of ruminants are smaller than those of other mammalia; and the smallest yet known are those of the little chevrotain and Napu musk-deer, of which the average diameter is less than $\frac{1}{12000}$ of an inch.[7] An examination of the elaborate tables by Mr. Gulliver shows that the size of the corpuscles in mammalia is not unconditionally proportionate to the size of each animal, or according to the nature of its food. Yet there is evidence enough that in each great division of the class, the size of the blood-corpuscles is, with few exceptions, directly proportionate to that of the animal's body; and that, in general, those of omnivora are larger than those of carnivora, and those of the latter larger than those of herbivora; so that if the kind of food and the size of the mammal be known, the size of its blood-corpuscles may be probably estimated.

In birds there is a greater uniformity of size and shape in the blood-corpuscles than in mammalia, and, according to Mr. Gulliver, a nearer relation between their size and that of the body. They are the smallest of the elliptical blood-corpuscles, those of the camel tribe excepted; they are generally rather less than twice as long as they are broad, measuring about $\frac{1}{2000}$ by $\frac{1}{4000}$ of an inch, and about six times as long as they are thick. In reptiles, the largest and, by

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justice of the award given in the text by consulting A. Kircher, (Scrutinium Phys. Med. Pestis, Lips. 1659, p. 240 and the context); Malpighi, (De Omento, Pinguedine, &c. p. 42;) and his Autobiography in the Opera Posthuma, (pp. 25, 92, in the Fol. Ed.;) and Swammerdam, (History of Insects, first published in 1669, at p. 31, of Hill's edition of 1778.) Lists of the principal writers on the blood-corpuscles may be collected from the General Anatomies of E. H. Weber, Gerber, and Henle.

[1] This remarkable and unexplained exception was discovered by Mandl in the dromedary and alpacha (Comptes Rendus des Seances de l'Acad. des Sc., Dec. 30, 1839), and has been amply confirmed.

[2] R. Wagner, (Lehrbuch der Physiologie, B. i. 153.)

[3] Wagner, Lehrbuch, and Beitrage zur vergleich. Physiologie. But he regards them as only chyle-corpuscles.

[4] Mandl, (Anatomie Microsc. p. 17.) Owen (Contributions to the Comp. Anat. of Blood-discs, Lond. Med. Gazette, Nov. 15, 1839) says most of them are $\frac{1}{4}$ larger than human blood-corpuscles. According to Gulliver (Appendix to Gerber's General Anatomy, p. 42,) the average diameter is $\frac{1}{2475}$ of an inch, which is nearly accordant with Mandl's statement.

[5] Gulliver, *l. c. All the sizes are stated in fractions of an English inch.*

[6] Perhaps the strictest measurements are those of Mr. Bowerbank for Mr. Owen *l. c.* In these the average was $\frac{1}{3687}$, the extremes being $\frac{1}{4545}$ and $\frac{1}{3279}$. Copious lists of the measurements by different observers are given by Köstlin, (Mikroskop. Forschungen, p. 55;) in the Microscopic Journal, vol. i. and in Mandl, *l. c.* p. 10.

[7] Owen, *l. c.* Dec. 20, 1839; and Gulliver, *l. c.* p. 44.

comparison, the thinnest, blood-corpuscles yet known occur; and Wagner[1] remarks it as a general rule, which Mr. Owen confirms, that the longer the branchial apparatus persists, the larger are the blood-corpuscles. Thus, in the Proteus they are about $\frac{1}{350}$ of an inch long, in the Syren $\frac{1}{435}$ by $\frac{1}{108}$[2]; in the batrachian reptiles generally, about $\frac{1}{1000}$ by $\frac{1}{3000}$; and their thickness is not more than one eighth of their length.[3] This rule, however, fails when one comes to fish, in which the branchial apparatus is persistent and perfect; for in them the blood-corpuscles, though resembling those of reptiles, are generally smaller and less elongated.[4]

b. Structure and Composition. The blood-corpuscles are generally regarded as primary nucleated cells, and no one doubts that those of birds and the lower vertebrata consist of an external cell, formed of an extremely delicate, soft, and elastic membrane, in and within which all the colouring matter seems to be contained, and of an internal parietal nucleus, generally similar in form to the cell, but about one fourth its size, colourless, and in the large corpuscles of some of the amphibia containing a number of distinct granules.[5]

It is questioned, however, especially by Valentin, Wagner,[6] and Gulliver, whether the corpuscles of mammalia have nuclei, or whether the central spot be not merely produced by the accumulation of the colouring matter at the circumference. Henle[8] would decide the question by saying that, in a few of these small corpuscles, there are nuclei; but that in the majority (and these the most fully developed,) there are none; so that he thinks it probable that here, as in some other cases, the nucleus, after the cell is perfected, is gradually absorbed.

According to Dr. Barry,[9] the young blood-corpuscle in all the vertebrata is a mere disc, with a depression in the centre. In mammalia it retains this form; in the other classes the disc becomes a nucleated cell. The nucleus at first communicates by a pellucid orifice ("nucleolus") with the exterior of the corpuscle, this orifice occupying the place of the depression in the original disc. The orifice becomes narrower, and the nucleus finely granular, and these changes immediately precede the division of the nucleus into minute discs. The discs, whose number is multiplied by successive divisions and by the gradual appropriation of the nucleus from its circumference towards its centre, arrange themselves so as to form a flat filament, having an appearance the same as that which he finds to be presented by fibre in all the filamentous structures of the body. According to the number of discs, this filament forms within the blood-corpuscle either a ring (as in man and most mammalia, where they are comparatively few), or a coil (as in birds, amphibia, and fishes, where the discs are much more numerous, and the filaments proportionally longer.)

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[1] Lehrbuch, p. 153. [2] Gulliver, in Appendix to Gerber, p. 52.

[3] In the cryptobranchus japonicus (in which there is no persistent branchial apparatus) they measure $\frac{1}{172}$ by $\frac{1}{731}$ (Van der Hoeven, Tijdschrift fur Naturl. Geschiedenis, 1841, p. 270,) but considering the great size of the animal, these enormous blood-corpuscles are not disproportionate.

[4] The anarrhicus lupus presents an exception in this respect. Its corpuscles measure $\frac{1}{1730}$ by $\frac{1}{3730}$. (Van der Hoeven, *l. c.*, p. 272.)

[5] In the blood-corpuscles of the Siren, as many as 20 or 30 granules can be seen in one plane of the nucleus. (Owen, in the art. *Siren*, Penny Cyclop.) The proportionally-longest corpuscles are those of the crocodilus lucius: they measure about $\frac{1}{950}$ by $\frac{1}{2538}$ of an inch. (Mandl, Comptes Rendus, Dec. 23, 1839.) Those of the Croc. acutus have the usual elliptical form, their longer diameter being about twice as great as the shorter. Gulliver, Lancet, Sept. 10, 1842.

[6] Lehrbuch der Phys., i. 154. [7] *L. c.* Appendix, 13, and Phil. Mag., Aug. 1842.

[8] Allgemeine Anatomie, p. 432.

[9] Philosophical Transactions, 1841, &c. The description in the text has been kindly furnished by Dr. Barry himself. Compare, for confirmation, Mayer, Ueber Primitivfasern in Blute, (Froriep's N. Notizen, April, 1841.)

The filament thus formed is flat and deeply grooved on both surfaces, being thereby thinner in the middle than at the edges. The edges are rounded; and when seen on its edge, the filament at first sight seems to consist of segments separated from one another by oblique lines. When perfected, the filament undergoes various changes: sometimes unwinding itself into a straight fibre; at others, continuing circular, while smaller coils of similar filaments are formed within it from a residual portion of the nucleus. In all cases the filament is reproduced by self-division, so that out of a single filament a fasciculus may be formed. Such changes are seen going on in coagulating blood. The filaments now mentioned exactly resemble those which are found in a great many both animal and vegetable tissues, nor can any definite line of distinction be drawn among the gradations from them to the double spiral filament, of which Dr. Barry believes that the primitive fibrils of muscle, and certain other tissues, are composed.

In all cases in which a nucleus is present, it differs in chemical characters from the cell. The colouring matter, or hæmatosine, is easily soluble in water, by which it may be completely washed out of the enveloping cells. The latter are composed of a peculiar albuminous substance (*globulin* of Berzelius), which only slowly dissolves in water; the nuclei consist of a different albuminous substance, more like coagulated fibrine, which is quite insoluble in water, and they contain so large a quantity of inorganic matter, that they completely retain their form, and, apparently, their substance after combustion.[1]

Purpose. Dr. Barry's and others' facts make it nearly certain that the blood-corpuscles take an important part in nutrition, if not in providing the materials of the tissues ready formed, yet in giving them their due capacity for development. In some cases of reparation, indeed, as of fractured bones, the Hunterian opinion that the effused blood becomes the bond of union is strengthened by the knowledge of the changes which the blood-corpuscles may undergo; but the present evidence is insufficient to make it probable that they, or any formed parts of them, are effused in ordinary nutrition. Wagner and Henle suppose that during all their circulation, the blood-corpuscles, by the energy which they like other primary cells may possess, are occupied in giving to the blood the constitution necessary for nutrition, secretion, &c. And this seems highly probable. It is not so reasonable, for example, to suppose that the effects of respiration are finished in the lungs, as to believe that the influence of the oxygen dissolved in the blood, is accomplished during the general circulation, through the medium of these cells with which it is continually in contact, and which might be compared to floating gland-cells.

II. LYMPH AND CHYLE CORPUSCLES.

In the villi of the small intestines, the chyle is a pure milk-white albuminous fluid, which does not spontaneously coagulate; its opacity is due to a number of minute oil-globules, varying according to the nature of the food, which float in it without any mixture of fibrine, or of the peculiar corpuscles which afterwards appear. Some of these particles of oil, distinguished by their immeasurably minute size, and by a more general similarity of character than the others present, are described by Mr. Gulliver[2] as forming the *molecular base* of the chyle.

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[1] See Harting, (Gissingen betreffende de eerste vorming der cellen, &c., Tijdschrift voor naturl. geschiedenis en physiologie, 1841, 8 Deel;) an essay pointing out several remarkable analogies between the forms assumed by certain inorganic precipitates (such as those of the carbonates of lime and iron) and the forms of the nuclei and cells of organic tissues. See also Link, (Poggendorf's Annalen, Bd. 46). The best microscopico-chemical analysis of the blood-corpuscles is in Wagner, (Lehrbuch, p. 160.)

[2] In Gerber, Appendix, p. 88. See also his contributions, &c. Philosophical Magazine, June 1842.

Besides these constituents, the more mature chyle, especially after it has passed through lacteal glands, contains the proper *chyle-corpuscles*,[1] or cells, which are colourless, moderately transparent, roundish bodies, some larger, some smaller than blood-corpuscles, apparently composed of numerous granules arranged round one or more central molecules. These are probably produced by the development of a cell around a nucleus formed by an aggregation of a number of the minute oil-globules which constitute the molecular basis;[2] and, as the corpuscles appear and increase, the oil-globules diminish, and the chyle, acquiring a greater proportion of fibrin, becomes more firmly coagulable.

The lymph-corpuscles closely resemble those of the more perfect kind in the chyle. Some of them are generally discernible in the blood, moving, as it circulates in the capillaries, in the peripheral portion of the current. They are somewhat larger than the blood-corpuscles, (into which it is most probable that they are ultimately developed,) white, strongly refracting light, roundish and granular, or mulberry-like.[3] Their probable mode of development by the aggregation of granules has been already mentioned.

III. FAT-CELLS.

There are several instances of cells containing oil at certain periods of their development, but those to which the name of fat-cells is peculiarly given, are the minute vesicles which, lying in the areolæ of the fibro-cellular tissue, constitute the adipose tissue. These are true primary cells, whose contents are oil instead of the albuminous fluid with which most are filled.[4] They are, for the most part, nearly spherical, and vary from $\frac{1}{200}$ to $\frac{1}{1300}$ of an inch in diameter:[5] their membranes are structureless, and though remarkably thin, are, by the water which they contain in their pores, impermeable by the oil within them; and they are usually aggregated in bunches traversed and enveloped by fibro-cellular tissue, conveying small blood-vessels.[6] Sometimes each cell bears on its wall a nucleus;[7] and in their early periods the oil in each is not in a single drop, but is composed of one comparatively large and several small drops, which subsequently coalesce.[8]

A fact may be mentioned here by which Ascherson[9] has endeavoured to explain the development, not of the fat-cells alone, but of all primary cells; namely, that if a minute drop of oil be placed in contact with a solution of albumen, it directly becomes coated with a film of the latter, so as to resemble a fat-cell. Any one may observe the fact in preparations in which a greasy bone is put in weak spirit: for wherever the oil oozes slowly, the bone becomes covered with this artificial fat, for which the filmy envelopes are furnished by the albumen dissolved in the water of the diluted alcohol. It is not probable that the fact admits of an extensive application in the physiology of cell-development: yet there is sufficient analogy between these artificial products and such bodies as the minute corpuscles of the chyle, the granulated oil globules (*corps granuleux*) of the milk, and some others, to render it probable that their developmental process is in great measure the same.[1]

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[1] Discovered by Leeuwenhoeck, and first well described by Hewson.

[2] They do not indeed act similarly on the application of chemical tests; but the observations of Ascherson, presently to be mentioned, show how it is possible that in their aggregation the minute molecules may have their apparent chemical properties modified.

[3] The fullest history of the chyle and lymph is in Nasse, (Unters. zur Physiologie und Pathologie, bd. ii.; and in Gerber (Appendix by Gulliver). See also Carpenter's Principles of Human Physiology, p. 460.

[4] Malpighi (De Omento, &c.) first described the adipose tissue with some accuracy. Fontana (Traité sur le Venin de la Vipère, &c.) first clearly described its elementary cells; to Raspail (Nouv. Syst. de Chimie organique) and Schwann (Mikroskopische Untersuchungen), however, are due nearly all the more important facts regarding their minute structure.

[5] See E. H. Weber (Hildebrandt's Anatomie, bd. i.), and Krause (Anatomie des Menschen, bd. i.)

[6] These are admirably figured by Mascagni (Prodromo della grande Anatomia).

[7] Schwann (Mikrosk. Untersuch., &c. p. 144); Bruns, (Allgemeine Anatomie, p. 32.)

[8] Schwann, (*l. c.*) Henle, (Allg. Anat., p. 181.)

[9] Ueber den Physiol. Nutzen der Fettstoffe, Muller's Archiv, 1840.

IV. CUTICLE.

The physiology of cuticle has received an altogether new aspect from recent investigations, and especially from those of Henle.[2] He has shown that, with very few exceptions, all the free surfaces of the body, both those of the integuments, of the serous cavities, of the mucous tracts, of the blood-vessels, and of the gland-ducts, are invested by a membrane composed of one or more layers of primary cells, forming a cuticle or epithelium.

Forms and arrangements. The elements of these cuticles, however, have not all the same form; and while they all serve the common purpose of protecting the tissues beneath them, many, perhaps all, add special functions to which they are adapted by a peculiar form or energy of their elements. They are all, in their complete state, formed of nucleated cells, in which, while the cells in different parts present many varieties, the nuclei are generally round or oval, flat and colourless, or reddish;[3] and the latter contain one or two distinct small nucleoli, and others very pale and small, and varying in number. The nuclei measure from $\frac{1}{5755}$ to $\frac{1}{3760}$ of an inch in diameter,[4] and the nucleoli about $\frac{1}{10}$ as much. The cells are usually clear and colourless, but are sometimes beset with minute points.

According to the form of the cells, Henle[5] distinguishes three varieties of epithelium; but they are not separated by strict differences, for whenever a continuous surface bears at different parts two different epithelia, there is a very gradual transition from one to the other.

The first is the *tesselated* or *pavement-epithelium*, which is composed of one or more layers of flat, oval, roundish, or polygonal cells, each about $\frac{1}{1900}$ of an inch in diameter, and containing a nucleus of the same shape, which again contains one or more distinct, and several paler, granules. This is by far the most common form of cuticle: it covers the skin, and lines the ducts of the cutaneous glands, the mouth, conjunctiva bulbi, pharynx, œsophagus, numerous gland-ducts, the vagina and cervix uteri, the entrance of the female urethra, the serous and synovial membranes, blood and lymph vessels, and a few other parts; and,

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[1] The minute anatomy of the secernent glands might find its place here, since it is probable the real agents of secretion are isolated primary cells: but most of the glands are of so complex a structure, that it will be desirable to describe first some more of their component parts.

[2] Before these investigations the existence of the greater part of the internal cuticles was argued rather than proved. Leeuwenhoeck (Select Works, by Hoole, vol. ii. p. 126,) first described with some accuracy the scales of the epidermis and of the epithelium of the mouth and vagina. Della Torre and Fontana (Traité sur le Venin, &c., t. i. f. 8-10,) more clearly described the cells and their nuclei in the mucus of the eel; then Raspail, Breschet, and others gave accounts of similar cells in the epidermis; and then the cuticles of many different parts were described by Purkinje, Valentin, and other German anatomists. The existence (not the structure) of the epithelium of the intestines was shown by Lieberkuhn (De fabrica et actione Villorum). There is a complete history of the observations in this part of structural anatomy in Henle, (Allgem. Anat., p. 259.)

[3] This colour exists particularly in the nuclei of the youngest and deepest layers, (Henle.) Dr. Barry (*l. c.*) points it out as one among many analogies between the epithelium-cells and the blood-corpuscles.

[4] Henle, Allg. Anat., p. 222.

[5] Ueber die Ausbreitung des Epitheliums, Müller's Archiv, 1838; and Allgemeine Anatomie, p. 220, from which nearly all this account of cuticles is derived.

as a general rule, has a thickness directly proportioned to the friction and other sources of injury to which it is exposed.

Cylinder-epithelium, the second variety, is found from the cardia, along the remainder of the digestive canal, to the anus, in most of the gland-ducts that open on the interiorof this tract, and in the greater part of the male genito-urinary apparatus and the gland-ducts connected with it. It is composed of closely-set cells of a somewhat conical, pyramidal, or cylindrical form, about $\frac{1}{1200}$ of an inch long, whose apices are attached to the mucous membrane or to flat epithelium-cells lying on it, and whose bases, which are usually terminated by a truncated plane about $\frac{1}{6000}$ of an inch broad, are free. Each such cell encloses, nearly mid-distance between its base and apex, a flat nucleus with nucleoli.

In the *ciliary epithelium*, which constitutes the third variety, cells like those in the second have several fine, pellucid, blunt ciliæ, about $\frac{1}{50000}$ of an inch long, attached to their free extremities. These, by means of some unknown power, are during life in constant motion, either whirling their free extremities, so that their ends describe circles, or waving continually backwards and forwards, and alternately rising and falling. Examples of this kind are found on every part of the respiratory mucous tract above and behind an imaginary plane drawn from the base of the nasal bones to the anterior maxillary spine, even into the air-cells, in the lachrymal sac and canals, along the Eustachian tube, and on the membrana tympani, on the palpebral conjunctiva, the cerebral ventricles, the commencements of the capsules covering the Malpighian bodies,[1] and in the female genital organs, from the middle of the cavity of the uterus through the Fallopian tubes, and for a short distance on the peritoneal surface of the latter.

The modes in which the elements of these several cuticles are connected are equally various. In the tesselated epithelium the component cells, when there are several layers, generally lie confusedly one over the other; and those in each layer adhere by their edges with the smallest possible quantity of intercellular substance, their mutual pressure usually making each cell polygonal. In the cylinder variety, the cells are generally almost in contact at their fixed extremities, while their free portions are immersed in a soft intercellular substance, which fills all the spaces between them, and forms a smooth surface over them.

Modes of development and growth. What has been said of the structure of cuticles, plainly indicates the change that must be admitted in their physiology. They are, in the most proper sense of the term, organized; for, besides the peculiar definite form of their elements, each cell has in itself the power by which it is developed, and depends on the subjacent vascular tissue only, as all other elementary structures do, for the supply of the materials which it may use for its own nutrition. These materials before they attain their ultimate form, undergo several changes, which have been best traced in the laminated varieties of the tesselated epithelium, including the epidermis and the thickest of the epithelia of the mucous membranes. In all these, the youngest layers, that is, those which lie next the vascular membrane or *matrix*, seem to consist merely of reddish nuclei, and these formed by an aggregation of granules; the cells, if there be any, being too small to be discerned from the nuclei which they contain. As these are moved from the matrix by the new materials successively deposited beneath them, both the nucleus and the cell, which is soon obviously developed upon it, grow larger; but the cell outstrips the nucleus, and at length assumes the usual appearance of an oval, nucleated corpuscle. As they become older and still more distant from the matrix, the nucleus either remains stationary or grows gradually more obscure, while the cell still increases in size, but becomes flat, dry, polyhedral, or quite irregular; and at the last (as one sees daily in the outermost layers of the epidermis) falls

[1] Bowman, (Cycl. of Anat.—*art.* Mucous Membrane;) who denies, also, the existence of ciliary epithelium in the air-cells.

off alone or united with many of its fellows in a shapeless scale. In the same progress also its chemical constitution is altered: at first the cell dissolves easily in acetic acid; at last it assumes the peculiar characters of horn, and is altogether insoluble in that fluid.[1]

In the cylinder epithelium the mode of growth is the same as far as the formation of the cell around the nucleus; but afterwards, instead of retaining nearly the same shape, the cell enlarges more in one direction than in the other; and in the ciliary variety it proceeds to the production of vibratory ciliæ from one of its extremities.

Purposes. The uses of cuticles are probably, as already mentioned, various. One is to protect subjacent parts, another to render certain surfaces smooth. But many may have more active offices. It will be seen that the elements of the most energetic secretory organs have only the same structure as these have; and it is not improbable, for many reasons, that the epithelium-cells also prepare and carry off with them, when they desquamate, some peculiar fluid. The ciliary cells probably serve to fan onward the fluids and the minute particles in contact with them. The direction in which they act is most commonly, but not constantly, towards the external orifice of the canal on which they are placed; but in truth their special purpose is in many instances (e. g. the cerebral ventricles) as uncertain as the power by which they act.[2]

V. PIGMENT-CELLS.

In certain parts there are special organs for the production of colour, namely, in the pigmentum nigrum and uvea of the eye, in the membrane of the ampullæ in the internal ear,[3] in the whole of the epidermis of the negro and other coloured races, and in that of the scrotum, the areolæ of the breasts, the labia and some other parts of light-complexioned persons.[4] In most of these the pigment is composed of minute, dark granules, collected in primary cells. The latter, when they lie loosely, as they do on the iris, are oval or round; but when, as in the pigment of the choroid, where they are most distinct, they are set closely and in an even layer, their mutual pressure makes them almost regularly hexagonal. They are nearly flat, about $\frac{1}{1800}$ of an inch in diameter, and lie in apposition so as to form a beautifully tesselated membrane. Sometimes their edges are in contact, sometimes slightly separated by a pale line. Near the middle of each there is a clear spot, produced by the nucleus of the cell, in which there are usually one or two nucleoli; and around this the pigment-granules are arranged. They are most numerous in its immediate neighbourhood, are less thickly collected at a little distance from it, and at the very margin of the cell there are often none at all. They are collected also only at the posterior surface of the cells on the choroid; the anterior portion of each cell (that is, that part which is turned towards the cornea,) contains the nucleus, and is quite transparent.[5] In the negro's epidermis, perfect pigment-cells, like those of the choroid, are found only in the deepest layers, and are most

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[1] It hardly need be pointed out that these facts prove the distinction of a rete Malpighii from the epidermis to be artificial.

[2] See, on all that relates to them, Sharpey, (Cyclopædia of Anatomy, art. *Cilia;*) Purkinje and Valentin, (Muller's Archiv, 1835, and Br. and For. Med. Rev., vol. i. p. 509); Pappenheim, (*ibid.* 1840, p. 510.)

[3] Wharton Jones, (Cyclopædia of Anatomy, *Organ of Hearing,*) to whom also is due the first accurate description of the pigm. nigrum; See Edinb. M. and S. J. xl. p. 77.

[4] Simon, (Ueber die Structur der Warzen, &c. Muller's Archiv, 1840, p. 151.) The black matter of the lungs and bronchial glands has no special apparatus. That which tinges expectoration seems deposited in ordinary mucus-corpuscles, (Martin Barry, Phil. Trans., 1841, p. 226, Pl. xx., f. 72.) The dark colour of many superficial nævi, of liver spots, and of freckles, is due to cells of pigment like those described in the text, (Simon, *l. c.*)

[5] Henle, Allgem. Anatomie, p. 281 and 158.

numerous at the bottoms of the fossæ between the papillæ. They do not differ from those already described, except in being smaller and in forming several layers; they sometimes seem to have separate granules, not inclosed in cells, mixed with them; and similar granules held together by the tenacious substance in which they lie are found in the uvea.

The pigment-granules are among the minutest structures in the body. They are flat, oval corpuscles, measuring about $\frac{1}{20000}$ of an inch in their longest diameter, and about $\frac{1}{4}$ as much in thickness: so that, according to the direction in which they are seen, they appear flat or linear or like mere points.[1] When set free by the bursting of the cell, they exhibit a very active molecular motion; and Schwann has noticed the same occurrence even while they are inclosed. It is only when aggregated that they give their full dark colour; when isolated they are nearly pellucid, or their borders only appear dark.

VI. NAILS.

Bruns[2] alone has accurately described the structure of the nail in the adult. It consists of primary cells, almost exactly similar to those of the epidermis, firmly fixed together in several layers. The youngest cells (those which lie at the root and in the deepest layers of the body of the nail,) are pellucid, round, elongated, or polygonal, and contain a round, granulated nucleus, with some other granular substance. They measure about $\frac{1}{1000}$ of an inch in their greatest diameter, and their nuclei are about $\frac{1}{10}$ as large. The oldest and most superficial cells are larger and broader, but much thinner and more irregular in their shape. Their nuclei are rarely discernible; between the old and new cells, those which are intermediate in situation are so in structure also. The striæ and fibres, described by Gurlt,[3] are due, Bruns says, to the section of the cell-membranes; the granules of Tourtual[4] are traces of the nuclei.

The growth of the nail is effected by the constant generation of cells at its root and at its under-surface; and this process is carried on with the energy necessary to repair the constant waste, both at the free extremity and the exposed surface. As the successive layers are pushed forward and toward the surface, each cell becomes larger, drier, and flatter, and more firmly fixed to those around it. The identity of the structure of the young cells of nail and of epidermis, renders the question, whether the epidermis be continued under the nail, one of words only: their early development is the same.

VII. CARTILAGE.[5]

True Cartilage. The proper substance of true cartilage is a homogeneous and nearly transparent white basis, in which there are numerous small, round, oval, or flat and elongated, or sometimes angular, cavities (*cartilage*

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[1] Henle, *l. c.* p. 284.

[2] Lehrbuch, p. 197. Before examination he makes the nail very soft by immersing it in an alkaline ley. His description exactly confirms what Schwann had proved of its development.

[3] Unters. über die hornigen Gebilde, (Müller's Archiv, 1837.)

[4] Hornstoff im Kropfen, (Müller's Archiv, 1840, p. 254.)

[5] According to their minute structure the parts commonly called cartilages and fibro-cartilages may be thus divided (Henle):—1. True Cartilages: the articular (with some exceptions presently mentioned), the costal, ensiform, nasal, trochlea, and those of the whole respiratory tract (with a few exceptions). 2. Fibrous Cartilages: the intervertebral ligaments, the synchondroses, the cartilages of the ear, epiglottis, and Eustachian tube, the Santorinian and Wrisbergian, the sterno-clavicular interarticular discs, and the cartilages of the inferior maxillary articulation. 3. Ligamentous discs: the interarticular ligaments of the lower jaw, wrist, and knee-joints (except the sharp edges of the latter,) the tarsal cartilages, the glenoid and cotyloid ligaments, and the fibro-cartilages of the sheaths and pulleys for tendons.

corpuscles), from $\frac{1}{1000}$ to $\frac{1}{3300}$ of an inch in diameter.[1] They usually seem to be mere cavities hollowed out in the basis-substance; but, by long boiling the latter is nearly dissolved, while they remain as distinct corpuscles; and sometimes a lining membrane is discernible in them.[2] They are, therefore, to be regarded as genuine cells, whose walls, during their development, have amalgamated with the intercellular substance.[3] Each such cell encloses one or more round nuclei which contain nucleoli, and sometimes are surrounded by cells, so as to give those first mentioned the character of *parent-cells*, that is, of cells enclosing a second generation of cells. The secondary contained cells vary in number, and have usually the form which mutual pressure gives them as they enlarge. The nuclei are often filled by fine particles of oil, which are at first isolated, but may coalesce, and, when very numerous, may fill their cavities so as to make them look like fat-cells; and when this takes place, the cavity of the primary cell also usually contains particles of oil. But in all these respects, as well as in the character of the contents of the primary cell, whether they be cells or nuclei, and in the mode in which the contained corpuscles are separated or attached to the parent-cell, the varieties are manifold and as yet unexplained.

The number of the cartilage-corpuscles, and the direction in which they are arranged, are more regular. In the articular cartilages, they are most numerous and smallest in the part most distant from the bone. All of them have their long axes vertical to the surface of the bone, except a thin layer of those next the joint, which are flattened, and lie parallel to the articular surface. Hence it is that such a cartilage will crack vertically to near its free surface, and then tears transversely. In all other cartilages, also, most of the corpuscles are set vertically to the surfaces, but there is a superficial layer in which they are flattened and lie parallel to them. In the cartilages of the ribs, the internal corpuscles are arranged in rows which radiate from the axis.

The substance in which the corpuscles are imbedded is usually homogeneous and structureless, but in certain cartilages it gradually assumes a finely fibrous aspect, and ultimately becomes truly fibrous.[4] With these changes two others coincide: namely, the formation of fat in the nuclei of the cells, and the acquirement of the yellowish colour in the place of the pearly blue of young cartilage; and all these appear to be preparatory to ossification, for they are never seen in cartilages in which that change does not take place.[5]

Fibrous Cartilages. The fibrous structure of some of the cartilages just described makes the transition to the fibrous cartilages, properly so called. In these there are corpuscles similar to those in the preceding variety, (except that the nuclei most commonly contain oil,) but the fibres are much darker and coarser, and form the greater part of the tissue. In different examples the directions of the fibres vary: in some, as the symphysis pubis and intervertebral ligaments, they are parallel; in others, as the cartilages of the ear and epiglottis, they frequently bend, and seem as if they were matted together.

Between these fibrous cartilages and the ligamentous discs which are usually called fibro-cartilages, there are also intermediate structures; the fibres of the fibrous cartilages are not like those of tendinous tissue: those of the ligamentous discs are. But in some examples of the former (the sterno-clavicular and inferior maxillary interarticular ligaments, for instance,) the chief sub-

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[1] Meckauer, (De penitiori cartilaginum structurâ, Breslau, 1836.) For measurements in different specimens, see Bruns, *l. c.*, p. 215.

[2] Bruns, Allg. Anat., p. 215.

[3] See Schwann, (Mikrosk. Untersuch, &c.;) Henle, (Allgem. Anat., p. 794.)

[4] These fibres are not demonstrated by snapping a cartilage asunder: the fibrous appearance of the broken surfaces, and the direction of the grain, are due to the arrangement of the cartilage corpuscles.

[5] Henle, Allgem. Anat., p. 798.

stance is traversed by fasciculi of the fibrils of cellular tissue, and thus the transition is established from them to the ligamentous discs, which are composed entirely of that tissue.

Development. In the earliest state yet seen, cartilage consists of its corpuscles set very closely in a soft homogeneous cytoblastema, and containing a clear fluid and an oval nucleus on which they were probably developed. As the corpuscles increase in size, so does the intercellular substance in quantity and density; and gradually the walls of the former are amalgamated with the latter, so that they deserve the name which Henle has given them of cartilage cavities, rather than that of cells. With this coalescing, the cavities of the corpuscles sometimes become smaller as if by a lamellar deposit on the interior of their walls. New cells are at the same time produced within the older ones, or in the intercellular substance, or in both at once. In the first case two or three cells form within one parent-cell; in the second, new nuclei are generated, and on these cells form as in the first development. To this condition the development of all cartilages is similar; the progress to the several varieties, is or will be described. The growth of cartilage (distinct from its development,) is effected by the addition of cytoblastema to the surface of that which already exists, in a manner similar to that of the growth of bone.

VIII. BONE.

Bone is composed of a basis of apparently homogeneous substance[1] (a compound of cartilage and earthy matter,) in which are densely scattered minute cavities with delicate branched canals. The cavities (or bone-corpuscles,[2]) are round or oval, and flattened; they measure from about $\frac{1}{2400}$ to $\frac{1}{1680}$ of an inch in length, from $\frac{1}{7200}$ to $\frac{1}{4000}$ in breadth,[3] and are about $\frac{1}{6}$ as thick as they are long.[4] They have somewhat jagged edges, from all parts of which there proceed fine branching canals (calcigerous canals[5]), which traverse the basis substance, and communicate irregularly with one another. The diameter of each canal, at its largest part, is between $\frac{1}{11000}$ and $\frac{1}{20000}$ of an inch; that of the smaller branches is between $\frac{1}{40000}$ and $\frac{1}{60000}$.[6] Müller[7] and Henle[8] have held that the corpuscles and canals are the chief seats of the bone-earth; but Mr. Smee[9] has rendered it more probable that they contain no solid matter, by showing that they can be filled with Canada balsam, and that, in the bones of those who have been embalmed, they are full of a waxen material; and Bruns[10] has found them empty in calcined bones, and perfectly transparent in very thin sections. At most, therefore, the earthy matter is only more thickly deposited in the walls of the corpuscles and canals than it is elsewhere.

True bone always presents these elementary structures, and is thus clearly distinguished from many morbid substances which are called ossifications, but which consist of amorphous or crystalline deposits of earthy matter. Its coarser structure is variously arranged in different parts, but always preserves a general character of lamellæ arranged round tubes and cellular spaces. The compact structure consists of osseous laminæ from $\frac{1}{5000}$ to $\frac{1}{3000}$ of an inch thick,[1] firmly united in concentric tubes, or in parallel planes, accordingly as the bone is cylindrical or flat.[2] They are most distinct on the exterior of bones, for there they are rarely interrupted by the canals for blood-vessels, which more internally are interposed in great numbers between them, and send off branches which pass through them. They appear either homogeneous or pellucid, or a little granular, (like ground glass,) or sometimes very finely fibrous, like the fibrous portion of the second class of cartilages;[3] and this last appearance is met with especially in cartilages ossified late in life, as those of the larynx, ribs, &c.

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[1] An exception will presently be mentioned in which it seems to be fibrous. Dr. Carpenter (Principles of Human Physiology, p. 511,) thinks that it is entirely composed of cells adherent together, and filled with a perfectly homogeneous substance.

[2] They were obscurely seen by Leeuwenhoeck (Select Works, vol. ii. p. 120), and badly figured by Mascagni, (Prodromo, Tav. x., xix.) They were first clearly discerned by Purkinje, and described by his pupil Deutsch (De penitiori structurâ ossium, diss. inaug., Breslau, 1834.) They have since been chiefly illustrated by Müller, Miescher, Schwann, Henle, Smee, and Bruns.

[3] Miescher, (De Inflammatione Ossium, p. 42.) The measurements of Valentin, Krause, Bruns, and others are sufficiently confirmatory.

[4] Henle, Allg. Anat., p. 828.

[5] These also were discovered by Purkinje, and more clearly described by Müller.

[6] The latter from Müller, in Miescher, p. 268; the former from Krause. Both are confirmed.

[7] In Miescher, p. 268.

[8] Allg. Anat., p. 829.

[9] On the Structure of normal and adventitious Bone, (Med. Gazette, Nov. 20, 1840.)

[10] Allgem. Anat., p. 241.

The blood-vessels of the compact structure of bone are conveyed in long cylindrical canals, (*Haversian canals*,[4]) of which the chief run straight in the spaces between the laminæ. These give off small branches which pass obliquely through one or more laminæ,[5] and form communications between the longer canals in different planes, so as to make up a coarse network of bony tubes permeating the compact structure; they open externally to admit vessels from the periosteum, and internally they merge by a kind of gradual expansion into the cells of the cancellous tissue. They are usually cylindrical, and they vary in diameter from $\frac{1}{200}$ to $\frac{1}{800}$ of an inch,[6] those nearest the surface being three or four times smaller than those near the cancellous tissue. Their walls, which are from $\frac{1}{300}$ to $\frac{1}{400}$ of an inch thick, are formed by from five to fifteen concentric lamellæ[7] of bone: and thus, each Haversian canal, whether its course be longitudinal or transverse, is surrounded, as the whole shaft of each cylindrical bone is, by a series of tubes, arranged concentrically about its axis. The bone corpuscles lie thickly scattered and as if compressed between the lamellæ, and are so placed that one of their largest surfaces is turned from, the other towards, the axis of the canal. The calcigerous canals run both between and through the several lamellæ; and, since many of them are directed towards the axis of the Haversian canal, they look like a set of faint striæ radiating from it to the outermost lamellæ. Their apertures are discernible in small dots on each lamella, and, according to Krause[8] and Mr. Smee,[9] on the interior of the Haversian canals, into which they believe that some of them open.

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[1] Müller, Deutsch, &c.

[2] The microscope was hardly needed for thus deciding the question whether bones are formed of lamellæ. The evidence of old Gagliardi was conclusive. Certain diseases separate these coarser lamellæ; and after softening in acid some may be dissected from all bones.

[3] Henle, (Allg. Anat., p. 826)—Malpighi, (Anat. Plantarum, p. 20, &c.) De Lasône, (Mém. de l'Acad. R. des Sc., 1751, p. 98,) and others described bones as formed of laminæ composed of filaments; but these were artificially-made fibres, altogether different from those which are discernible but not separable.

[4] From Clopton Havers, who described them very fancifully in his Osteologia Nova, in 1729.

[5] They form the little processes which Gagliardi (Anatome Ossium, 1689) described as nails. The accuracy of his account of the structure of bones merits something very different from the ridicule commonly attached to his name: the description of Clopton Havers, which is usually praised, is not nearly so good.

[6] Miescher, &c. $\frac{1}{300}$ to $\frac{1}{500}$. Bowerbank, in Medical Gazette, Nov. 20, 1840. They are best seen in sections of the flat bones of the skull, made in planes parallel to the surface.

[7] They are called lamellæ for distinction from the *laminæ*, just described.

[8] Handbuch der Anatomie des Menschen, b. i., p. 71.

[9] Medical Gazette, *l. c.*

Each Haversian canal contains an artery and a vein, which pass along its axis, surrounded by a very soft fat, to which they distribute minute branches. The vessels of the external canals are derived from the periosteum; those of the internal ones from the vessels of the medullary tissue; and the two sets freely anastomose.

As already said, the canals of the compact tissue gradually merge into the cells of the cancellous; and in both the type of structure is the same; for each cell also contains soft fat in which the minute branches of the medullary artery ramify, and the walls of each are formed by a series of delicate lamellæ, with corpuscles and canals arranged in the manner already described.

Development. All bones are developed through the medium of cartilage: even in those which seem to be produced in membranes, the cartilaginous state intervenes between the membranous and osseous. The development of cartilage to the state ready for ossification is described. The cartilage corpuscles become the bone-corpuscles, but the exact nature of the changes which they undergo is not certain. (See page 7.) Whatever it be, the deposition of earthy matter does not commence till the canals from the corpuscles and those for the blood-vessels are formed, and the latter have received their supply of blood.

The Haversian canals are believed to be formed by the parent cartilage-cells, or cartilage cavities elongating and coalescing in connected longitudinal and transverse series. At the parts which are not about to ossify the cells lie almost singly; but where that change is at hand, numerous young cells are aggregated within parent-cells in lines which have the same directions as the subsequently-formed vascular canals. The youngest cells then dissolve, and the canal formed by the coalesced parent-cells becomes filled by a transparent semi-fluid gelatinous substance (the *cartilage-medulla* of Miescher), into which the newly-formed blood-vessels enter from the periosteum, and in which they give off branches as afterwards they do in the Haversian canals. The cancellous tissue is developed on the same plan; but the canals formed are much shorter, and their communications more numerous. The laminated and lamellated structure is not discernible till after the formation of the canals, but it seems to precede the deposition of the earthy matter. The latter begins in the intercellular substance and the vascular canals, in which minute dark granules are deposited evenly or in heaps; the corpuscles and calcigerous canals afterwards have their walls densely ossified and the process is completed.

IX. TEETH.

In no organs have the results of recent microscopic researches[1] been so unexpected or so brilliant as in these. They have revealed structures before unknown in each of the three component parts of the tooth.[2]

Cement, *crusta petrosa*, or *bone*, forms the outermost layer of the teeth, and in its minute structure differs in no respect from common osseous tissue.[3] It visibly surrounds the whole fang, being thickest near the apex and on the grooves; and Mr. Nasmyth[1] has shown that it also extends in a very thin layer over the enamel of the crown. The existence of this substance which, if not always vascular, can probably easily become so, explains the possibility of engrafting teeth upon the vascular tissue.[2]

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[1] The chief discoveries were made coincidently by Purkinje, of Breslau, and Retzius, of Stockholm. The former published his observations in 1835, in the dissertations of Fränkel (De penitiori dentium hum. structurâ), and of Raschkow (Meletemata circa dentium evolutionem); the latter in the Transactions of the Royal Academy of Stockholm, and afterwards in Müller's Archiv, 1837. See Br. & For. Med. Rev. viii. 158. Interesting as were the facts they revealed, they are far surpassed in importance by the application which Mr. Owen, in his admirable Odontography, has made of the minute structure of the teeth as evidence in determining the general and specific relations of extant and fossil animals. It must be regretted that more use cannot be made of his work in so limited a report as this.

[2] Malpighi (Anat. Plantarum Idea, p. 19, and Op. posthuma, p. 53,) seems first to have described all the three substances. He calls the bone *materia tartarea*, the enamel *substantia filamentosa*, and the dentine or ivory *substantia ossea*. The bone was subsequently overlooked till the time of Purkinje and Retzius.

[3] Its structure always coincides with that peculiar to the bone of each species. (Owen, *l. c.* xx.)

Enamel invests only the crown of the teeth, and is composed of solid prisms or fibres, about $\frac{1}{5600}$ of an inch in thickness, set side by side upright on the ivory. One end of each prism is fixed in a little depression on the rough outer surface of the ivory; the other, which is somewhat larger, is turned towards the masticating surface of the tooth in that direction which is best for resisting external force. The course of the prisms is more or less wavy, their curves being, for the most part, parallel, but sometimes opposed. Most of them reach the surface of the tooth; and where they do not, small complemental prisms fill up, like wedges, the vacancies. In the perfect state the enamel contains a scarcely discernible quantity of animal matter, and its prisms are inseparably consolidated; but in young teeth it is soft, and may be broken up into its elements. In this early state it exhibits portions of a membranous animal substance, consisting of the cells in which each of the fibres was enveloped;[3] for the earthy matter is deposited, as it were, in a set of moulds, formed by the coalescing of the primary cells of the enamel-membrane; and as it accumulates, the cell-membrane is so far removed, that in the perfect tooth no trace of it can be discerned; unless, indeed, as Retzius suggests, the fine close-set transverse striæ which go round the whole or part of each prism indicate the remains of it.

The *Dentine* or ivory forms the chief mass and body of the tooth. It is composed of a fibrous basis traversed by very fine, branching, cylindrical tubuli,[4] which run in an undulating course from the pulp-cavity, on whose interior they open, towards the adjacent part of the exterior of the tooth. Each tubule in its course outwards makes two or three curves, (*primary curvatures*, Owen,) and is, besides, bent at every part into numberless minute and very close undulations, (*secondary curvatures*, Owen;) but the course of those tubules which are adjacent to each other is as nearly as possible parallel.[5] The chief ramifications of the tubules are dichotomous; but they also frequently give off minute branches, which, again sending off smaller ones, fill up the spaces between the trunks. At the trunk each tubule has an average diameter of about $\frac{1}{10000}$ of an inch, and the distance between each two tubules is about equal to the width of three. Towards the outer surface of the ivory, the tubules and their branches are immeasurably fine, and some of them pass from the ivory into the bone, and open into the canals of its corpuscles. Both the walls and cavities of the tubules, as well as the substance between them, are filled by the earthy constituent of the ivory which lies in fine granules. The basis of the intertubular substance is composed, according to Henle,[6] of bundles of flat, pale, granular fibres, whose course is parallel to that of the tubules.

Development. According to Mr. Goodsir,[7] who has admirably illustrated the opinion first distinctly announced by Arnold, the first appearance of the pulp of each tooth is in the form of a minute papilla, rising from the bottom of a

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[1] Three Memoirs on the Teeth and Epithelium; and Med.-Chir. Trans., vol. xxii.

[2] As in Hunter's experiments of grafting the tooth in the cock's comb, and of transplanting teeth from one person to another. Owen; Odontography.

[3] Schwann, Ueber die Uebereinstimming, &c., p. 118.

[4] Malpighi is commonly quoted as having noticed the tubular or fibrous structure of the ivory; but whoever will examine the places already referred to will find that he never saw the tubules, and only discovered a coarse fibrous network like that of which he wrongly supposed the bones to consist.

[5] Henle, Allgem. Anat., p. 854.

[6] *L. c.* p. 856. Mr. Nasmyth considers it to be cellular, (Memoirs.)

[7] On the Origin and Development of the Pulps and Sacs of the Human Teeth. Edinb. Med. and Surg. Journ., v. 51. p. 150.

groove in the mucous membrane of the mouth, behind the edge of the jaw. Next, as the borders of the groove grow around it, the papilla seems to sink in the mucous membrane, and appears as if rising from the base of a follicle. Lastly, processes of membrane or *opercula* grow from the sides of the mouth of the follicle, and convert it into a capsule or sac. These three stages of the formative organs, the *papillary*, the *follicular*, and the *capsular*, being completed, the substances of the tooth begin to be formed; namely, the dentine in the papilla, which assumes the form of the tooth-pulp; the enamel in a tissue or enamel-pulp developed from that part of the sac which is opposite to the papilla; and the bone in the sac itself, or in a tissue produced by it.

The space between the papilla or pulp and the interior of the sac enlarging by the growth of the latter, there is deposited within it a soft, granular, non-vascular substance, the enamel organ.[1] At the same time there is formed on the surface of the papilla a peculiar structureless membrane—the preformative membrane[2]—which, when the pulp begins to ossify, presents numerous little elevations and depressions, in which the enamel-fibres are afterwards fixed; for as the pulp enlarges the preformative membrane comes in contact with the enamel organ, and they are moulded the one on the other.

The tubules of the dentine and the prisms of the enamel are formed by transformation of the primary cells of which the pulp and the enamel-organ are respectively composed. The superficial pulp-cells, which are at first round and nucleated, assume the same diameter and regular direction as the dentine tubules, and then have earthy matter deposited within and around them. And these changes go on gradually through the pulp from without inwards; as fast as the cells of one layer are ossified, those of the layer beneath elongate and arrange themselves regularly in preparation for the same change; and so on, until a great part of the pulp is ossified.[3] The pulp then begins to grow onwards into the jaw, forming one or more processes, by the similar ossification of which the fangs are formed: and the tooth is thus made to rise to the surface of the gum. In the formation of the enamel the primary nucleated cells on the inner surface of the enamel-organ become elongated and cylindrical or polygonal; they assume a direction vertical to the surface of the pulp; and their nuclei disappearing, they are hardened by the deposition of earthy matter within them, and they coalesce into the complete prisms. These changes, like the preceding, make progress in layers, but from within outwards, till nothing is left but a thin *enamel membrane* on the surface of the crown of the tooth. By the transformation of this or of the sac itself, (or, more probably, by the ossification of a material effused from them as from a periosteum,) the investing layer of bone or cement is formed. During the hardening of the pulp the preformative membrane disappears or is ossified.

X. HAIR.

Most of the hairs consist of two distinct substances: an external, cortical, hard, and fibrous part, and an internal, medullary, granular portion, on which their colour chiefly depends.[4] Moderately magnified, hairs look like empty tubes, but in fine transverse sections no central apertures can be seen.

The *cortical part* of the hair is fibrous. Very delicate longitudinal striæ may be traced on it, becoming more faint as they pass from the root to the tip, and in general invisible at a little distance from the latter. They are traceable through the whole thickness of the cortical substance to the very wall of the medullary portion, and indicate the outlines of the component fibres. The latter are, according to Henle,[1] each about $\frac{1}{4000}$ of an inch in breadth, flat, rigid, and brittle, with dark and rough edges. But they may probably be further split, for, after maceration in hydrochloric acid, Bidder[2] found the diameter of the thickest part of a single fibre to be only $\frac{1}{27000}$ of an inch, and Bruns[3] about $\frac{1}{9000}$; so that probably each of the fibres whose course is marked by the striæ is made up of several smaller ones. In some hairs, moreover, the fibres appear at certain parts, either irregularly or at definite distances, enlarged; and thus the whole shaft sometimes assumes a beaded appearance.[4]

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[1] External pulp, of Hunter, (Natural History of the Teeth). Organon Adamantinæ, of Purkinje, *l. c.*

[2] First noticed by Mr. Bell, (Hunter's Works, v. ii., p. 39, note.)

[3] Hence the concentric rings of coloured dentine in young animals fed on madder. The successively elongated cells must also be fused at their extremities, so as to form continuous tubes. It is uncertain when the branches are given off, and how they communicate with the bone-corpuscles.

[4] The medulla is absent in the fine hair over the general surface of the body, and at the very root and near the tip of all hair.

Besides these longitudinal striæ, indicating the fibrous structure of its cortical part, the surface of the hair is marked by transverse and oblique, and sometimes apparently spiral, wavy lines arranged in a very close series. Meyer[5] has shown that these are formed by the slightly projecting edges of tiers of minute scales, like those of the epidermis, but much smaller, which, being closely imbricated in whorls one over the other, invest the whole surface of the hair, and form a sheath around its cortical part, extending nearly to its tip. They make the hair look as if it were irregularly *hooped* round; or rather, when the hair is very strong, as if it were a closely-jointed reed.

The *interior medullary portion* of the hair is darker than the exterior and granular. It is composed, for the most part, of very minute globules, like pigment-granules, or drops of oil agglomerated in small lumps, and enclosed in a membrane which lines the tube of cortical substance. Sometimes these granules form one dark mass, continued along the whole shaft of the hair; but more commonly the mass seems broken up, so that there are intervals of different sizes along the axis of the shaft. These are sometimes filled by a substance like the cortical part, and the medullary matter then seems altogether deficient; but more often they are occupied by a colourless substance, clearer and softer than the exterior fibrous tissue. The diameter of this medullary part, when it is completely formed, is about $\frac{1}{3}$ or $\frac{1}{4}$ of that of the whole shaft; transverse sections of hairs exhibit it like a nucleus, with a clear ring around it; along its walls there are often complete pigment-cells, with clear nuclei and transparent membranes.[6]

At the tip the hair gradually becomes more and more fine, and usually ends in a rounded point, at and near which neither striæ nor medullary substance can in general be seen. At the root it rather suddenly enlarges into a funnel-shaped extremity, which Henle has named the *knob* of the hair, and which is about three times as wide as the shaft. Just before the hair begins thus to enlarge, the transverse striæ produced by the outermost layers of imbricated scales, are very distinct and broad; but they suddenly cease to be discernible. At the same part the longitudinal striæ become finer, and seem to diverge. But, in addition

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[1] Ueber die Structur und Bildung der menschlichen Haare, (Froriep's N. Notizen, April, 1840, and Allgem. Anatomie.)

[2] Einige Bemerk. über Enstehung, Bau, und Leben der menschlichen Haare, (Müller's Archiv, 1840, p. 538.)

[3] Allgem. Anatomie, p. 204.

[4] Bidder, *l. c.*

[5] Froriep's Notizen, 1841, and in Henle, Allgem. Anat. p. 294. Henle coincides in this view: he had formerly (Fror. Notiz., April, 1840,) considered the transverse striæ to be due to bands of a substance resembling the elastic tissue wound round the bundles of fibres forming the shaft; a view which closely agrees with that of Dr. Barry, who believes that the hair has the same general structure as the muscular fibre, &c., and is composed of a fasciculus of flat, double-spiral fibres, held together by wider coalesced spirals. Valentin (Repertorium, 1841,) and Reichert (Müll. Arch. 1841, clxxvi.) entirely confirm Meyer's description.

[6] Meyer, *l. c.*

to these, the knob is marked by coarse, dark, longitudinal striæ, which look like short, interrupted furrows, but which are produced by small, flat, metamorphosed nuclei, about $\frac{1}{1200}$ of an inch long, and $\frac{1}{18000}$ broad. They are largest at the upper part of the knob, and are often tortuous or connected together by fine filaments; lower down they are broader and oval or spindle-shaped, and lower still they pass into roundish or angular granules, like the nuclei of the rete Malpighii. They lie closely in a firm, pellucid substance, and sometimes seem surrounded by cell-membranes, among which, in dark hairs, numerous pigment-granules are scattered.[1]

The *knob* of the hair and the nearest part of the shaft are pretty closely invested with a membrane, for which Henle proposes the name of the *sheath*, and of which some or the whole is pulled out when a hair is plucked from the skin. It is continuous with the epidermis, and may be regarded as the epithelium lining the hair-follicle. It is composed of two layers, of which the outer and thicker is yellowish, granular, and thickly set with superficial nuclei; the inner clear and much thinner, and perforated, like a *fenestrated membrane*, by numerous round, oval, and elongated apertures, but having no trace of cells or fibres. Below, the two layers are united together, and with the exterior of the knob; above, a small space filled with fatty matter intervenes between them and the exterior of that part of the shaft of the hair which is below the surface of the skin.

XI. CELLULAR AND FIBROUS TISSUES, OR FIBRO-CELLULAR TISSUE.[2]

All the tissues which have passed under these names nearly agree in their microscopic structure: their chief anatomical differences depend on the mode in which their elements are aggregated. The common material of which they are composed consists of fine, transparent, undulating, cylindrical filaments, from $\frac{1}{30000}$ to $\frac{1}{10000}$ of an inch in diameter.[3] They are generally collected in fasciculi, from $\frac{1}{3750}$ to $\frac{1}{7500}$ of an inch wide, the filaments in which are connected by a firm, structureless cytoblastema; and the fasciculi either merely adhere together, or, as in the case of tendons and other similar tissues, dense bundles are united by others of more loosely connected filaments placed in their interstices. In different parts either dense or loose fasciculi, or both, are woven into cords, membranes, &c.

In certain situations the elements of the fasciculi are bound together by small filaments of another kind, which, from their supposed origin, may be named *nucleus-filaments*, and which Henle[4] discovered by immersing fibro-cellular tissue in acetic acid, so as to make its proper fasciculi transparent. The latter are thus seen to be severally, and sometimes collectively, constricted at pretty regular distances by one or more dark filaments, very similar to those of elastic tissue, which either wind spirally round them, or encircle them with distinct rings. This arrangement is most frequent when the fasciculi form cords; in other cases (for instance, where many fasciculi lie parallel, as in tendons and strong membranes,) similar dark filaments run, not spirally, but straight along the interspaces between each two fasciculi; and in others (in which the tissue is very lax,) the dark filaments are very numerous and run tortuously, or are even twisted up into little balls.

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[1] See also on this subject some remarks by Mr. Busk, in the Microscopic Journal, vol. i. p. 26, and vol. ii.; and Simon, Müller's Archiv, 1841, and Brit. & For. Med. Rev. xiii. 525: and on the structure of the hair in general, Reichert, *l.c.*, 175; who believes that the cortical substance is composed of concentric layers of rigid, pellucid membrane, longitudinally fissured. On the development of hair see Henle, Reichert, Meyer, and Bidder, *l.c.*; among whom there is so much difference, that it is impossible to state briefly what is most probable.

[2] This compound term seems preferable to either of its components. *Fibrous* and *cellular* are both terms applicable to many tissues besides this; but *fibro-cellular* may well indicate a tissue composed of fibres which are in some cases woven so as to inclose imperfect cellular spaces.

[3] Treviranus (Beiträge, bd. i.), Jordan (Ueber das Gewebe der Dartos, Müll. Arch. 1834), Gerber (Allg. Anat., p. 123), Henle (Allg. Anat., p. 348), and many others nearly agree in these measurements. Lauth (Nouv. Manuel de l'Anatomiste, &c.) and Krause (Handb. der Anat., bd. i.), make them much greater.

[4] The best tissue for demonstrating this is that which forms the fine fibres connecting the nerves and vessels at the base of the brain; but a similar arrangement exists in nearly every variety. See on that in the pia mater of the spinal cord Purkinje and Luening, (Valentin's Repert. 1841.)

Other forms discerned in fibro-cellular tissue thus treated with acetic acid are those of oval corpuscles, like dark cytoblasts, and of elongated, curved, or tortuous striæ, drawn out at their ends. The corpuscles commonly lie in rows with their axes parallel to the proper fasciculi of the tissue; and very often they are connected by longer and more slender bodies, so as to form continuous, undulated, and spiral filaments. Henle, therefore, (to whom all the account of these fibres is due,) has little doubt that the elongated nuclei represent the early state of the dark *spiral* and *interstitial nucleus-filaments*; and that, on the other hand, there is a regular gradation from the latter to the filaments of genuine elastic tissue; for all the transitional forms are found mixed with the proper fasciculi in different varieties of fibro-cellular tissue. Again, there is in another direction a transition from the fibro-cellular to the muscular tissue; for though most of the organs composed of the former seem to serve passively their purpose in the economy, yet some, though not distinguished by their structure, have more active properties and contract under appropriate stimuli. Such are the fibro-cellular tissues of the skin and of the dartos, which in their minute structure exactly resemble, on the one hand, the ordinary connecting fibro-cellular tissue, and on the other, the iris[1] and the longitudinal and circular contractile coats of veins and lymphatics, from which there is an easy gradation, both in function and structure, to the genuine organic muscles.

The *development* of the cellular and the elastic tissues may be traced in the introductory observations, (pp. 7-8.)

XII. ELASTIC TISSUE.

(*Tissu jaune élastique.*) In the preceding section the lower forms of this tissue, of which individual fibres are connected with fasciculi of fibro-cellular tissue, are described; in the higher forms of it its peculiar fibres compose independent fasciculi, with which subordinate quantities of fibro-cellular tissue are mixed.[2]

The fibres of elastic tissue resemble, in general, flat, solid[3] bands, of various sizes, from $\frac{1}{4000}$ to $\frac{1}{22500}$ in width.[4] They are peculiarly distinguished by their sharp, smooth, dark edges, their frequent appearance of branching, their tendency to form arches or curls when their extremities are free, and their brittleness, so that they easily break into short pieces with abruptly cut-off extremities. According to the predominant arrangement of their fibres, Henle divides all the

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[1] Krause, Handb., b. i. On the dartos, see Bowman, *l. c.*, who says that it contains organic-muscular fibres.

[2] Henle, Allg. Anat. 399. The best previous accounts were those of Eulenberg (De tela elastica, diss. inaug., Berol. 1836), Schwann (Encycl. Worterb. der Med. Wissenschaften, *art.* Gefässe), Räuschel (De arteriarum et venarum structurâ, diss. inaug. 1836), and Lauth (L'Institut, t. ii. 1834), by whom the peculiar minute structure was first discerned.

[3] Purkinje and Räuschel (*l. c.*) believe that they are tubular, having seen a small dark spot, like a section of a canal, on transversely divided portions of the fibres, and a line of points arranged along the middle of their surfaces. The latter observation, which has been often repeated by Valentin (Repertorium, ii.) and others, may also indicate that the fibre, apparently simple, is composed of two interlacing spirals, like the muscular and others in Dr. Barry's system.

[4] Henle, whose measurements are generally nearly confirmed.

examples of elastic tissue into three varieties. The first, of which the type is in the true vocal ligaments, differs only in degree from the interstitial form of the tissue which is combined with the fibro-cellular fasciculi. Its fibres are undulated, narrow, and very rarely branched or anastomosing; they form, however, independent fasciculi, which are connected by small quantities of the fibro-cellular tissue. In the second variety, which includes the ligamenta subflava, (the most perfect of all the examples of the tissue,) the fibres are large and widely arched, and frequently give off branches. In the third, including the elastic coat of the blood-vessels,[1] the fibres are of smaller size than in the second, and very frequently anastomose so as to form, while they for the most part maintain one general direction, a network with meshes of various size.[2]

When the elastic fibres seem to branch it is doubtful whether a single fibre really splits, or a double fibre divides into its two component parts. Valentin,[3] Lauth, and Eulenberg maintain the latter view; Schwann, Bruns,[4] Henle, and most others, the former; and they regard a genuine branching and coalescing as the peculiar characteristics of these fibres. In Dr. Barry's opinion the reticular arrangement of some of the varieties of elastic tissue, whose fibres have the same general characters as those more simply arranged, affords a striking example of the breaking up of double spiral fibres into networks, which would find a close analogy in the formation of the reticular ducts of vegetables.

XIII. MUSCULAR TISSUE.

The transition in function, though not in structure, from the passive to the active fibro-cellular tissue, and from the latter to the organic muscular tissue, has been already alluded to. Among the tissues of the present class there are similar gradations in regard to their several functions;[5] but by their structure they may be definitely arranged in two main divisions: the first including the muscles of organic life, which (with one exception) consist of simple smooth filaments; and the second comprising the muscles of animal life and of the heart, which consist of compound and apparently striated fibres, or tubes, including fibrils.

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[1] To be more minutely described in another section.

[2] The elastic tissue occurs in distinct fasciculi in several parts besides these mentioned as types of its various arrangements. For instance, it is found in the bands and ligaments of the larynx and respiratory passages, in a layer surrounding the œsophagus, and in one between the muscular and mucous coats near the cardia and the anus, in the fascia lata, and several other fasciæ, where, besides the interstitial and spiral nucleus-filaments, many independent fasciculi exist. In these parts the arrangement is on the plan of the first variety. Similar fasciculi, but usually arranged in net-works, are found mixed in the tissue beneath the epithelium of several serous membranes, as the pleura costalis, the peritoneum on the anterior wall of the abdomen and on the fundus of the bladder, the ligaments of the liver, the intestines, &c. And, lastly, fasciculi like those of the ligamenta subflava, are mixed with the proper tissue of many parts of the skin. (See Eulenberg, Lauth, Henle, *l. c.*, and Bowman, Cycl. of Anat., *art.* Mucous Membrane.)

[3] Repertorium, bd. ii. &c.

[4] Allg. Anat. p. 75.

[5] The several members of this ascending series may be thus arranged:—1. Common connecting fibro-cellular tissue. 2. The tissue of the skin contracting under the influence of cold and mental emotions. 3. The dartos, which contracts more forcibly under the same influences. 4. The contractile coats of arteries and veins. 5. The iris, which contracts when its nerves are directly irritated, and with the quickness of muscle. 6. The lower organic muscles of the gland-ducts, &c.; and the higher of the stomach, urinary bladder, &c. 7. The muscle of the heart. 8. The perfect muscles of animal life. But it will be observed that the progress in structure does not coincide with this arrangement according to function. The tissue of the iris, for instance, is exactly like the lowest fibro-cellular tissue.

A. *Muscles of organic life.* No full account of this tissue was given before that by Henle, who investigated it in his search after the properties of arteries.[1] He says that the fibres, in their most perfect form, are flat, from $\frac{1}{4700}$ to $\frac{1}{3100}$ of an inch broad, very clear, granular, and brittle, so that when they break they often have abruptly rounded or square extremities. Some of them are uniform; a few bear nuclei; the majority are marked along the middle, or, more rarely, along one of the edges, either by a fine continuous dark streak, or by short isolated dark lines, or by dark points arranged in a row or scattered; and between these three kinds of marks there are such gradations as prove that they have all the same origin from nuclei. Fibres such as these are collected in divers numbers in fasciculi, upon which the dark lines just mentioned sometimes form, by branches which they give off and receive, a sort of network, and sometimes run tortuously, like the nucleus fibres of the fibro-cellular tissue. (See pp. 8, 26.)

Fibres of organic muscle, such as are here described, form the proper contractile coats of the digestive canal from the middle of the œsophagus[2] to the external sphincter ani,[3] of the urinary bladder, the trachea and bronchi, the ducts of glands, the gall bladder, the vesiculæ seminales, the pregnant uterus,[4] the arteries and the veins.[5]

B. *Muscles of animal life.* The voluntary muscles are composed of fleshy bundles inclosed in coverings of fibro-cellular tissue, by which each is at once connected with, and isolated from, those adjacent to it. Each bundle is again divided into smaller ones, similarly ensheathed and similarly divisible; and so on, through an uncertain number of gradations, till, just beyond the reach of the unaided eye, one arrives at the *primitive fasciculi*, or the *muscular fibres* peculiarly so called, the first fixed form in the system.[6]

1. *Structure.* The primitive fasciculi consist of tubes of delicate structureless membrane,[7] enclosing a number of filaments. They are cylindriform, or prismatic,[8] with five or more sides, according to the manner in which they are compressed by adjacent fasciculi. Their breadth varies in different animals, from $\frac{1}{60}$ to $\frac{1}{1500}$ of an inch; in man from $\frac{1}{200}$ to $\frac{1}{300}$, the average of the majority being about $\frac{1}{400}$.[9] Their most striking, though not constant, characteristics are their pale yellow colour, and their being apparently marked by striæ, which pass

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[1] Ueber die Contractilitat der Gefässe, (Casper's Wochenschrift, Mai 1840, and Brit. & For. Med. Rev. vol. x.), and Allg. Anat.

[2] On the Fibres of the Œsophagus, see the observations of Mr. Gulliver, Proceed. of the Zoological Society, part viii.

[3] In the fibres of the stomach and intestines there is often an obscure division into fine rigid fibrillæ; in those of the upper part of the ureters there is an approximation to the fibro-cellular fasciculi, for they gradually split into undulated fibrils, (Henle.)

[4] Schwann (Mikrosk. Unters. p. 167), Lauth (Müll. Arch. 1835, Jahresb. p. 3), and Baly, in Muller's Physiology. On those of the unimpregnated uterus, which resemble the undeveloped muscular fibres of the embryo, see Purkinje and Kasper, Froriep's N. Notiz. Marz 1842.

[5] See further, p. 39.

[6] They were first described by Hooke, in 1678. The account of them became gradually more accurate in the successive descriptions of Leeuwenhoeck, Muys, Fontana, and Prochaska.

[7] Valentin (Hecker's Annalen, 1835); Schwann (Mikrosk. Unters.) It is the sarcolemma of Mr. Bowman (Philos. Trans. 1840), whose complete description of it is generally confirmed by Henle (Allg. Anat. p. 579). The latter, however, adds that it is often absent; and that, when present, it bears numerous elongated nuclei like those on the fasciculi of organic muscle.

[8] Muys (Musculorum Artificiosa Fabrica, pl. i.); Prochaska (De Carne Musculari, p. 45); Bowman (*l. c.* Pl. xvi. fig. 1, &c.)

[9] Bowman (*l. c.*, p. 460). These measurements are generally confirmed by those of Raspail, Schwann, Skey, Henle, and others.

transversely round them, in slightly curved or wavy parallel lines, from $\frac{1}{10000}$ to $\frac{1}{12000}$ of an inch[1] apart. Other, but generally more obscure, striæ also pass longitudinally over the tubes, and indicate the size and direction of the filaments, or primitive fibrillæ of which the primitive fasciculus is composed.[2]

The *primitive fibrils* are the proper contractile tissue of the muscle. Each of them is cylindriform, but somewhat flattened, and about $\frac{1}{18000}$ of an inch in its greatest thickness.[3] They are marked by transverse impressions, which are at exactly the same distance apart as the striæ on the surface of the fasciculus. Hence it is generally concluded that, as Fontana believed, the striated appearance of the primitive fasciculi is produced by the filaments being so apposed that the transverse marks on all those near the surface lie at exactly the same levels.[4] At present there is much question of the true structure of the fibrils, and of the source of their seeming constrictions, or transverse impressions. Some deny the existence of such constrictions, except when the muscle is contracted, or in some particular condition after death;[5] some believe that the fibrils are rows of corpuscles, or discs, connected by a homogeneous transparent substance;[6] and Dr. Barry[7] regards the fibrils as a peculiar form of his grooved and compound filament; each being composed of two spiral threads, wound in opposite directions, and interlacing. In the second view, the transverse marks on the fibrils, and the ordinary striæ on the fasciculus, correspond to the spaces between the discs; in the last to the spaces between each two successive turns of one of the spiral threads; for since each filament has its edge turned outwards, only one set of coils can at first be seen.

Each primitive fasciculus contains several hundreds of the fibrils; and when fully formed they fill all the cavity of the sarcolemma with the exception of very small interspaces, which seem occupied by a glutinous pellucid fluid.[8] It is only in immature fasciculi that there is an appearance of a central cavity, which is filled either by fluid or by minute granules.[9]

Where a muscle is affixed to a tendon, each primitive fasciculus of the former terminates in an abruptly rounded extremity, which is embraced by a fasciculus of tendinous fibrils, expanding and enclosing it as in a sheath.[10] The coarser fasciculi of tendinous filaments are also continuous with the fibro-cellular tissue which intervenes between the secondary fasciculi of the muscle.

2. *Action.* The actual phenomena of muscular contraction have been often

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[1] Schwann, in Müller's Physiologie, bd. ii. p. 33. Nearly confirmed by Prevost and Dumas, Lauth, Bowman, and others.

[2] Exceptions to these general characters are met with sometimes, but are not yet explained. See especially Gulliver in Gerber, p. 295, and Henle (Allg. Anat., p. 580).

[3] The measurements of Henle, Lauth, Ficinus, Bruns, and several others, pretty nearly agree with this statement.

[4] Dr. Barry, however, (Philosophical Transactions, 1842,) says there are states in which the fibrillæ have no share in the appearance of transverse striæ, and in which they are due to the flat and grooved filaments, which, he believes, are wound spirally and interlaced around the bundles of fibrillæ. Some of Henle's observations are strongly confirmatory of this view (Allg. Anat. p. 583); and perhaps Mandl's account (Anat. Microsc. p. 14,) is drawn from a similar appearance.

[5] Treviranus, (Beiträge, bd. ii.;) Ficinus (De Fibræ muscularis forma et structura;) Valentin, (De Functionibus Nervorum;) Skey, (Phil. Trans. 1837.)

[6] For examples (each, however, with some modification,) Lauth, Krause, Turpin, Schwann, Müller, Bowman, Bruns, and Gerber.

[7] *L. c.*, and Philosophical Magazine, April, 1842. Henle, (Allgem. Anat. p. 582,) confesses it impossible to decide the question, but he seems to think that the fibrils are not composed of rows of globules, but derive that appearance from being finely wrinkled. Fontana, also, (Sur le Venin de la Vipère, t. ii. p. 229,) remarked that the appearance seemed due sometimes to rows of globules, and at others to the mere wrinkling of cylinders.

[8] Skey, Bowman, Henle.

[9] Skey, Gerber, Henle; but see Valentin, p. 31.

[10] Valentin, Bowman, Bruns, &c.

examined in both the voluntary and the involuntary muscles, but the mode in which it is effected is still disputed. Hales,[1] and after him Prevost and Dumas,[2] described the contraction as the result of the primitive fasciculi being thrown into zig-zag lines. But the view of others (which has been especially illustrated by Mr. Bowman[3]), is that the change is effected by an approximation of the constituent parts of the fibrils (whether discs or coils), which, at the instant of contraction, without any alteration in their general direction, become closer, flatter, and wider; a condition which is rendered evident by the approximation of the transverse striæ seen on the surface of the fasciculus, and by its increased breadth and thickness. The appearance of zig-zag lines is referred by Dr. Allen Thomson and Mr. Bowman, to the relaxation of a fibre which has been recently contracted and is not at once stretched again by some antagonist fibre, or whose extremities are kept close together by the contractions of other fibres. Valentin[4] adopts a middle course of explanation, believing that the production of inflexions in the fibres depends on the degree of their contraction. Ordinary and moderate muscular contraction, he says, is effected by a vermiculation passing very rapidly over the whole length of the fibre, and in this act, the transverse striæ are approximated; but when the contraction is greater, geniculate (zig-zag) inflexions are produced, and become the more acute and close, the more violent the contraction. All agree in the account of the contraction commencing either at the extremity or at several intermediate parts of a fasciculus, and thence travelling over its whole length; so that the entire act is rather a succession of contractions and dilatations than a single contraction.[5]

In relation to the question of the connection between the muscular contractility and the nervous influence, the following observation by Valentin may be recorded, but perhaps should not be built upon without much caution.[6] He galvanised on the field of the microscope several minute portions of muscle, and observed whether they contracted or not, which it was possible to do with a moderately high power. Then, with a much higher, he examined whether, in each portion of muscle, there were any portion of nervous fibre included; and he found that in every case in which nerve was present contraction took place, but that when the portion of muscle contained no nervous fibre, the galvanism was ineffectual to produce the same result.

Development. Schwann's account has been already alluded to. It is that nuclei, with one or two nucleoli, form on a soft cytoblastema, arrange themselves in rows, and produce cell-membranes around them. The cells thus formed become filled by granules, elongate, coalesce by their extremities, and form long tubes, within which the fibrils are produced. The latter have at first the appearance of fine pellucid filaments, which are produced in layers from without inwards, so as gradually to fill the cavity of the tube or secondary cell; and as they are formed, the granules that were in the cells disappear, and the nuclei are pushed towards the wall. Valentin's[7] account differs somewhat. He thinks that

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[1] Statical Essays, vol. ii. p. 59.

[2] Mém. sur les Phénomènes qui accomp. . . de la Fibre musculaire. (Magendie's Journal, vol. iii. p. 301.)

[3] Phil. Trans. 1810 and 1841. See also Owen and Allen Thomson, in Hunter's Works, by Palmer, vol. iv. p. 261, note; and Martin Barry, *l. c.*

[4] De Functionibus Nervorum, p. 132. His observations were chiefly made by galvanizing portions of muscle on the field of the microscope.

[5] On the application of this to ruptures of muscles, see Mr. Bowman's Paper, in the Phil. Trans. 1841.

[6] And the more since it has not been confirmed, and Mr. Bowman says that in his experiments fibrils contracted after, as he believed, all adjacent tissues were completely removed. It is possible, however, that these were such spurious contractions as, according to Valentin, are produced merely by the action of water.

[7] Zur Entwickelung der Gewebe des Muskel-, des Blutgefass-, und des Nerven-Systems. Müller's Archiv, 1840. Henle (Allg. Anat. p. 600) nearly coincides.

the fibrils may be produced outside the tube formed of the coalesced cells, and that this latter may form (at least for a time) the wall of a central cavity which, he believes, always exists in the muscular fasciculus. The fibrils first produced are, he says, homogeneous and pellucid: they afterwards become varicose, and the muscle assumes its striated form: and hence the two kinds of fibrils may often be found, the simple in the interior, the varicose in the exterior, of the same fasciculus. He is also disposed to regard the sarcolemma as a secondary formation rather than as produced from the coalesced primary cells; believing that, in the cytoblastema remaining around each fasciculus of fibrils, nucleated cells are produced, which arrange themselves longitudinally, become long and narrow, and at last, by their fusion, form a sheath of fine varicose fibres. The nuclei of these external cells are what Schwann supposed to be the original nuclei pushed outwards from the interior of the fasciculus; Valentin believes that the original nuclei are absorbed together with the granules which at first filled the cells and the tubes formed by their coalescing.

XIV. NERVE.[1]

A. *Structure.* 1. *Cerebro-spinal nervous fibres.* In a nerve belonging to this system one finds numerous fibres enclosed in a common membranous sheath, or *neurilemma.* The latter is composed of fasciculi of fibro-cellular tissue, closely woven together in a generally longitudinal direction, and somewhat more wavy than the filaments in most varieties of this tissue; so that they give the nerve a satin like glistening aspect. Commonly, also, it has a characteristic striated appearance (the striæ being transverse or oblique, or even spiral), from a close alternation of bright and dark streaks, which are due to the fibres of the neurilemma being wrinkled,[2] or to the primitive nervous fibres within it being arranged in a slightly tortuous manner,[3] and which are destroyed by stretching and by maceration.

Within this common sheath the nervous fibres are assorted in subordinate bundles of nearly equal size, each of which is enclosed in a separate secondary sheath, continued from the external one, but composed of much finer and less perfectly developed tissue. Within each of these there are again subordinate divisions of the fibres similarly enclosed, till at last, arriving at the primitive fibres, each of these is invested by a covering analogous to the outer neurilemma, but possessing a fineness of structure proportioned to the minuteness of that which it envelopes. It is a most delicate membrane, exactly pellucid, and, in general, seems structureless; but Schwann[4] believes he has seen elongated nuclei in it, and Valentin[5] says he can, in favorable circumstances, see that it has a fibrous appearance, “ as, if two sets of fibres crossing one another ran screw-like round the nervous tube; a view which remarkably confirms the observation of Dr. Martin Barry.[6] A longitudinal arrangement of fibres is also sometimes discernible.[7] The proper substance of the nervous fibre, which is contained within the sheath just described, is, according to Valentin,[1] a clear opalescent, viscous, homogeneous, oil-like substance, without any trace of corpuscles, vesicles, or fibres. Henle,[2] confirming, on the whole, this account, describes each nervous fibre as resembling, in the living or just-dead state, a fine cylinder of clear glass, being pellucid and colourless, and having simple, well-defined, dark edges. But they agree that it is only immediately after removal that this simplicity of composition can be discerned; for very quickly, and especially when they are immersed in water, the fibres, as if by a coagulation of their substance, assume the appearance of being composed of two different materials.[3] In this state their edges are marked by dark parallel outlines, within which again are two internal lines, parallel to them and to one another, which make each fibre look like a tube.

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[1] A better example of the progress of minute anatomy in four years cannot be found than in a comparison of the following account with that in a review, in Brit. & For. Med. Rev., vol. vi., of what was known on the same subject in 1838.

[2] Prevost and Dumas, Valentin (Ueber den Verlauf und die letzten enden der Nerven. Nov. Act. Acad. Nat. Cur. 1836, p. 66.)

[3] Fontana, (sur le Venin, &c.;) Burdach, (Beitr. zur Mikrosk. Anat. der Nerven, Ann. des Sc. Nat. 1837, p. 117;) Henle, (Allg. Anat. p. 616.)

[4] Mikrosk. Untersuch.

[5] In Sömmering (vom Baue des mensch. Körpers bd. v. p. 5.)

[6] Henle has a less distinct description of a similar arrangement of interlacing spiral fibres around the primitive fibre (Allg. Anat. p. 620).

[7] Rosenthal, Valentin. Valentin (Repertorium, iii. 262) believes he has sometimes seen movements as if produced by ciliæ on the inner surface of this primary sheath; but he has not much confidence in his observation (Sönmering's Anatomie, bd. v. p. 6); and it has not been confirmed by others.

Regarding this last as their natural condition, Remak,[4] whose description agrees very nearly with that of Fontana,[5] considers each fibre as a delicate contractile tube, containing a pale flattened band (the *primitive band*) which, he thinks, is composed of several very fine solid filaments. Rosenthal,[6] also, whose description was written under the guidance of Purkinje, regards each fibre not as homogeneous, but as composed of an *axis-cylinder*, of moderately firm nervous matter, enclosed in a cortical portion of softer substance (*vagina medullaris*): and nearly the same view is entertained by Hannover[7] and by Schwann. Dr. Martin Barry, on the other hand, believes that the nervous fibre possesses a structure analogous to that of the primitive fasciculus of muscular fibrils; that the outer white substance (*vagina medullaris*) is a fasciculus of double spiral flat filaments, and the central portion (*Remak's band*) a filamentous material from which they are continually being given off.

Whatever be the true original structure of the nervous fibre, its cylindrical is soon exchanged for a beaded or varicose form, from the accumulation of the contents into separate masses, which dilate small portions of the sheath while the intermediate spaces collapse; and these changes proceeding, the contents of the sheaths, either spontaneously or by the influence of the fluid in which they are placed, assume a granular or curdy appearance, and may be easily pressed out. From the supposition that these states are natural, arose the errors in the first descriptions of minute nervous structure by Ehrenberg[8] and others. The changes take place with the more facility, the more coarsely the fibres are dissected, and the finer and more delicate their investing sheaths are.[9] They are therefore quickly produced in all the fibres of young subjects, and in those of the brain and spinal cord, and of the nerves of peculiar sensation, at all ages. Hence Ehrenberg was led in his first essay to make a marked distinction between the *varicose fibres* in these nerves, and the cylindric fibres of others;

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[1] In Sömmering, p. 5.

[2] Allg. Anat. 617. See also Klencke, Uber die Primitivnervenfasern.

[3] A fact remarkably confirmatory of this view, and of which the first notice is due to Mr. Clift, is the perfect transparency of the living or just-dead retina; it assumes the gray opacity by which it is generally known in the same time as the change here described is supposed to take place in the nervous fibres. Still, however, though the whole substance may, during life, seem homogeneous, its separation into two different materials when it is all subjected to the same influence, makes it most probable that the external and internal portions are really different in their composition.

[4] Obs. Anat. et Micr. de Systematis Nervosæ Structurâ, Froriep's N. Notizen, Juni 1838, and in several other papers.

[5] Sur le Venin de la Vipère, &c.

[6] Diss. Inaug. de formatione granulosâ in nervis, &c. in Valentin's Repertorium, 1840, p. 76, &c.

[7] Müller's Archiv, 1840, p. 552.

[8] Beobacht. einer auffallenden . . . Struktur des Seelenorgans, Berlin, 1836.

[9] On the influence of particular agents in producing these changes, see Burdach, *l. c.*, Valentin, and Henle who also gives a full account of the evidence on all the controverted subjects.

and although his own later observations, and those of all others, prove that all nervous fibres are alike, in their natural state, cylindrical, yet, as Remak has observed, the degrees of facility with which they severally assume the beaded form may serve to distinguish them as well as if they possessed it during life.

The size of the cerebro-spinal primitive nervous fibres is variable, and the same fibres have not the same diameter through their whole length. They are generally largest at their peripheral extremities and in their course along the nervous trunks, where the majority measure, in round numbers, from $\frac{1}{2000}$ to $\frac{1}{3000}$ of an inch in diameter.[1] They gradually decrease in size as they approach the brain, whether directly or through the medium of the spinal cord ; and in the brain itself they continue to grow less as they pass through the medullary to the cortical part, so that in the former they measure (on a similar general average) from $\frac{1}{7000}$ to $\frac{1}{8000}$, and in the latter not more than $\frac{1}{14000}$ of an inch.[2] The fibres of the olfactory and optic, and, in a less degree, those of the auditory nerves, are equally small in every part of their course, and thus resemble, in size as well as in structure, those portions of the other nervous fibres which are continued into the nervous centres. Remak[3] also observes that the primitive fibres for common sensation are smaller, and become more readily varicose than those for motion ; and Henle[4] confirms this in general, but adds that there is no distinct line of demarcation between the two sets, for that in all mixed nerves fibres of every gradation of size occur.

2. *Organic or sympathetic nervous fibres.* The general neurilemma is tougher in this than in the preceding class of nerves, and has a layer of circular fibres in addition to the longitudinal ones. The several fibres in a nervous trunk are seldom assorted in secondary or more subordinate fasciculi.[5]

In the nerves of this system there are, besides the fibres supposed to be peculiar to them, many of the same kind as those already described ; and the latter, which are always finer than the average of the ordinary nervous fibres, vary in their proportionate number in different parts. In the roots of the sympathetic they do not form more than $\frac{1}{4}$ or $\frac{1}{5}$ of the fasciculus ; in most of the nerves proceeding from the ganglia to the viscera they are more numerous ; in the main trunks, such as the splanchnic and the cardiac nerves, they greatly predominate ; and the ciliary nerves, as well as those of the lachrymal and mammary glands, and those which accompany the blood-vessels, are wholly composed of fibres like those of the nerves of common sensation.[6]

The nature of the other and peculiar fibres in the branches of the sympathetic nerves has been much disputed. They are described by Remak,[7] Pappenheim,[8] Muller,[9] and some others as distinguished by their fineness, paleness and yellowish hue, and by the constant absence of the lateral, dark lines which give the cerebro-spinal nerves the aspect of tubes. Rosenthal and Purkinje[10] consider them to be formed by an axis-cylinder similar to that of an ordinary nerve-fibre, and surrounded by a granular nucleated sheath ; so that they differ from cerebro-spinal nerve-fibres only in the absence of the outer medullary layer (*vagina medullaris,*) of the nervous substance. Henle thinks they are a peculiar set of nervous fibres arising from the central organs, put into connexion in the ganglia, and destined for the contractile fibro-cellular tissue and the blood-vessels.

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[1] Wagner and Krause, (Muller's Physiology, by Baly, i. 597;) Nasse, (Müller's Archiv, 1839, p. 245.) The measurements of several others agree. For comparison, see Ehrenberg, (*l. c.*) and Wagner, (in Burdach's Physiologie, bd. v.)

[2] Treviranus, (Beitrage, hft. ii.;) Henle, (Allg. Anat.)

[3] Vorlaufige Mittheilungen, (Müller's Archiv, 1836, p. 145,) and in other papers.

[4] Allg. Anat. p. 669. The difference is most perceptible in comparing the fibres of the anterior and posterior roots.

[5] Henle, *l. c.* p. 630.

[6] Ibid. *l. c.* p. 631-2.

[7] Neurologische Notizen ; Froriep's N. Notizen, Aug. 1837, and elsewhere.

[8] Die specielle Gewebelehre des Gehororgans.

[9] Archiv, 1839. Jahresb. cciv.

[10] De formatione granulosâ, &c., in Valentin, *l. c.*

He calls them *gelatinous* nervous fibres, and describes them as pellucid, flat fibres, between $\frac{1}{5000}$ and $\frac{1}{3750}$ of an inch in breadth, with numerous oval or round nuclei arranged at pretty regular distances on their flat surfaces, and more or less elongated and approaching the characters of other nucleus fibres. Sometimes also, he says, the nerve-fibre is split at its extremity like the fasciculus of fibro-cellular filaments in course of development.

On the other hand, Valentin,[1] who is, on both anatomical and physiological grounds, the chief opponent of the notion of a peculiar set of fibres in the organic nerves, regards those which are so described by others as merely the imperfectly-developed filaments of fine, fibro-cellular tissue, which are formed into sheaths for the investment, not of collections of nervous fibres, as in other nerves, but of each nervous fibre separately. These sheaths he believes to be continued over the fibres from ganglion-globules presently to be described.

The conflicting views may be probably reconciled according to the explanation by Volkmann and Bidder,[2] which has received the confirmation of E. H. Weber. It seems most probable that the fibres described by Remak are those of the investing membrane of the true sympathetic fibres, as Valetin holds, and which, in old frogs, exactly resemble the common wavy filaments of fibro-cellular tissue. (E. H. Weber.) But the true sympathetic fibres are still distinct from the cerebro-spinal, and were probably well discerned by Rosenthal and Purkinje. According to Volkmann and Bidder, they are distinguished by their fineness, (their diameter being constantly about half as great as that of the cerebro-spinal nerves,) their paleness, the absence under all circumstances of a double contour, the very small quantity of curd-like contents which they exhibit when decomposed, and their yellowish-gray colour when they lie in bundles. The difference in size between the cerebro-spinal and the sympathetic fibres is quite distinct; and though both sets of fibres vary to some extent, there is not nearly a complete series of gradations between them.

B. *Course.* The observations of Fontana and of Prevost and Dumas, confirmed by those of Muller[3] and others, prove that the nervous fibre is uninterrupted from its central to its peripheral extremity, and that in all that course there is no anastomosis or confusion of substance between any two primitive fibres—facts proved by both experiment and sight. They have received additional confirmation from Kronenberg[4] and Valentin,[5] the latter of whom examined particularly the nervous fibres in the recti oculi and other minute muscles of very small animals.

The microscope has also materially assisted Volkmann[6] in proving certain facts respecting the course of nervous fibres which could not have been discerned by ordinary dissection. Such, for instance, is the fact, that in several instances fibres proceed for a certain distance from the centres and then, without passing into the substance of any organ, form loops and return again to the brain or spinal cord; so that different parts of the nervous centres may be supposed to be connected by long, nervous fibres, arranged in arches, of which the extremities are at the centres, and the arcs far external to them. This is the case in the plexus of the descendens noni with the cervical nerves, through which some branches of the latter ascend to the brain; and probably also in the arched fibres which form the inner border of each optic tract, and the posterior border of the chiasma; and in those fibres which experiment has proved to proceed in arches from the posterior to the anterior columns of the cord, through

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[1] Ueber die Scheiden der Ganglienkugeln, &c. (Müller's Arch. 1839,) and elsewhere.

[2] Verhaltniss des Nervus sympathicus zu dem übrigen Nervensysteme beim Frosche, &c. in Froriep's N. Notizen, Marz 1842.

[3] Physiologie, bd. ii.

[4] De plexuum nervorum structurâ, Berol. 1836, and Müll. Arch. 1837, Jahresb. ii.

[5] Ueber den Verlauf. &c. p. 77.

[6] Beob. und Reflexionen ueber Nervenanastomosen, (Müll. Arch. 1840, p. 510), and Brit. and For. Med. Rev. Vol. XII. p. 239.

the roots of the nerves.[1] It has thus also been made not improbable that the two retinæ are connected by similar arcs, both extremities of which are peripheral; and perhaps there are some other similar instances.

By similar microscopic tracing, Volkmann and Bidder[2] have settled the important fact that the sympathetic nervous fibres form an independent system, whose centres are the ganglia. At the chief points of junction of the two systems some of the sympathetic fibres (traceable by the characters just described), run towards the spinal cord, others towards the periphery. The proportionate numbers passing in each direction vary in the different places of connexion. From the branches connecting the sympathetic with the eighth and ninth spinal nerves of the frog, for instance, scarcely any sympathetic fibres proceed centrally yet these are the largest of the branches which are commonly described as the *origins* of the sympathetic system from the spinal cord. On the whole, the sympathetic at these points of junction always gives more fibres that it receives. It must therefore have some source of fibres of its own; and this source is found to be chiefly in the ganglia, both spinal and sympathetic (specially so called,) and, in a less degree, in the cord itself.

If, it is argued, the sympathetic derived at these parts all its fibres from the spinal cord, such fibres ought to be found in duly proportionate number in the roots of the spinal nerves. But it is not so. In the case of the fourth spinal nerve of the frog, for instance, the branch connecting the sympathetic with it is larger than the fourth nerve itself. Therefore, since all the fibres of the connecting branch run centrally, they ought, if they have their origin from the spinal cord, to be found in great numbers in the roots; but there are fifty times more cerebro-spinal than sympathetic fibres in the roots of this fourth nerve. The sympathetic fibres which pass into its trunk cannot be traced further than to the ganglion on the posterior root. From this ganglion, therefore, they probably have their origin; and they are destined, as those in the other trunks are, chiefly to the posterior branches of the nerve. The anterior branches also contain sympathetic fibres, but they are derived, not from the spinal ganglia, but from those of the sympathetic itself.

c. *Modes of Termination.* 1. *Peripheral.* The arched arrangement of the nervous fibres already mentioned is repeated in the substance of the organs in which they are said to terminate; for, as far as they have been examined, the general, if not the constant, mode of termination is as follows: After repeated divisions into smaller bundles of fibres, the fasciculi, which consist of from two to six fibres each, form plexuses, whose arrangement bears a general resemblance to that of the elements of the tissue in which they are placed. These are the *terminal plexuses.*[3] Each fasciculus of the plexus next breaks up into its primitive fibres, and each fibre, either after passing over several elementary structures of the containing tissue, or, as in the sensitive papillæ, the iris, &c., after forming a single narrow loop, returns to the same or an adjoining plexus, and pursues its way back to the nervous centre, from which it set out. In other words, each fibre forms an anastomosis or *terminal loop* with another from the same or a neighbouring fasciculus. There is thus, strictly speaking, no more termination of nerves than of blood-vessels; both alike form circles. The characters of the fibres are scarcely altered in the substance of the organs receiving them: their sheaths become finer, but they are not lost or *laid down*, nor is there any fusion of the nervous into the adjacent substance.[4]

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[1] Magendie, (Comptes Rendus, Mai et Juin, 1839;) and Kronenberg, (Vers. ueber die motorische und sensibeln Nervenwurzeln, (Müll. Arch. 1839.)

[2] *L. c.*

[3] Valentin, Ueber den Verlauf, &c., and in Brit. and For. Med. Rev. Vol. XI.

[4] No mention is here made of the cells found near the peripheral distribution of the nerves of the higher senses, and supposed by Valentin and some others to be analogous to the ganglion-globules at the nervous centres; for they are not constant elements in the peripheral nervous structures, and Henle's opinion (Allg. Anat., p. 664) that they

But it is questioned whether this, which is the only really observed arrangement, be a just account of the distribution of the minutest elementary nervous structures. Another view of the whole matter must be taken if it be true that those which are called the primitive fibres be, as the observations of Treviranus,[1] Remak, and Martin Barry indicate, fasciculi, each containing several fibrils which, though they are not discernible in the substance of the tissues, may be distributed to their minutest parts. If it be so, the real ultimate arrangement of the nerves is utterly unknown. There are some imperfect observations respecting the distribution of the minuter fibres, by Schwann[2] and Remak.[3] But it must be admitted as a strong argument against the distribution of such finer branches, that the course of those already described as the ultimate fibres is clearly discernible, that they do not appear to give off branches, and that small as the finer divisions are supposed to be, they would not be less than the fibres of many other kinds which can be recognized in their respective tissues.

2 *Central.* When the nervous fibres have passed centripetally through the dura mater, the general neurilemma becomes thinner; and there is a still further reduction both in it and in the investment of each fibre when they have penetrated the superficial layer of the brain or spinal cord. In the same progress the size of the fibres gradually diminishes, and the tendency to assume the varicose form on the least injury of the investing membrane increases. Having entered the brain, whether directly or through the medium of the spinal cord, the fibres proceed in bundles (which are the coarsely demonstrated *fibres of the brain*) towards the cortical substance, forming on their way the most intricate plexuses, but never anastomosing. Arrived at the cortical substance, the fasciculi form plexuses among the gray globules exactly comparable with the terminable plexuses already described; and, at the last, the fasciculi, having broken up into their component fibres, or very small collections of them, these form loops in the cortical substance of the brain like the terminal loops in the substance of the tissues.[4]

The white substance of the spinal cord, like that of the brain, is composed

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are epithelium-cells covering the layer of the extremities of the nerves seems more probable than any hitherto offered. Their history may be found in his work, and in the essays on the retina referred to in a following note.

[1] Vermischte Schriften, bd. i. p. 129; and Beiträge, hft. ii. p. 39.

[2] Müller's Physiologie, bd. ii.

[3] Zur Mikrosk. Anatomie der Nerven, &c. In reference to the distribution of the nerves in each organ it must suffice to refer generally to Valentin's edit. of the 5th vol. of Sömmering's Anatomie, and his treatise Ueber den Verlauf und die letzten Enden der Nerven; and to Müller's and Carpenter's Physiologies. For particular organs the following references may be sufficient: for the *Retina:* Hannover, (Müller's Archiv, 1840, hft. iii.;) Grube, (ibid. 1840, and Microsc. Journ. 1841, p. 71;) Bidder, (Müll. Arch. 1841;) Remak and Henle, (ibid. 1840;) Gottsche, (ibid. 1834;) Henle, (Allg. Anat.;) Valentin, (Repertorium, bd. v. &c.) Reichert (Müll. Arch. 1841. Jahresb. which contains a good analysis of several of the preceding. The *Ear:* Wharton Jones, (*Hearing, Organ of,* Cycl. Anat.;) Pappenheim, (Die specielle Gewebelehre des Gehororgans;) Valentin, (Repertorium;) and Br. and For. Med. Rev. Vol. VIII. p. 68. The *Nose:* Treviranus, (Beiträge, hft. ii. p. 56.) The *Skin:* Valentin, (Ueber den Verlauf, &c.;) Burdach, (Beiträge, pp. 108, 161;) Breschet, (Recherches sur la Structure de la Peau.) The *Muscles:* Valentin and Burdach, *l. c.* The terminations in the ciliary ligament and iris, the tongue, the blood-vessels, and the teeth-pulps are also described by Valentin and Burdach. The latter shows that in general, though the rule is not universal, the sensitive nerves terminate in plexuses, or complex loops, the motor in simple loops.

[4] Nearly all the minute anatomy of the fibres in the nervous centres is due to Treviranus and Valentin. The arrangement in plexuses has been generally confirmed. It was first minutely described by Dr. Macartney in 1833, in his "Observations on the Structure and Functions of the Nervous System," (see Abstract in Med. Gazette, vol. xiv. p. 812.) The junction of fibres in central loops, first described by Valentin, has been confirmed by Carus (Einige Aphorismen aus der Phys. des Nervenlebens, Müll. Arch. 1839), and by Klencke (Ueber die Primitivnervenfasern, Gött. 1841), but by no other anatomist. Valentin himself has lately spoken very doubtfully of it (Repertorium, 1840, p. 96).

entirely of the continued nervous fibres. Bundles of them form intricate plexuses without anastomoses, and have all a general direction towards the brain. As far as the microscope can discern, the fibres as they ascend get nearer to the gray matter, being successively overlaid by those which abut upon the cord higher up than themselves; and the cord, as it passes from below upwards, is thus continually augmented by external layers of fibres, till it comes to the medulla oblongata.[1]

It is not probable that either the brain or the spinal cord contains any fibres but such as are continuations from those of the several nerves of the body: of these they form what Valentin has called a *condensed collection.*

C. *Structure of the Gray Nervous Substance.* The general character of this constituent of the nervous centres is that it is composed of numerous globules, called ganglion-globules, from $\frac{1}{300}$ to $\frac{1}{1250}$ of an inch in diameter, which are usually of a spherical or oval form, more or less flattened, and of a reddish colour. Each contains one or more nuclei with subordinate nucleoli, is enclosed in a very fine filamentous investment, and is often marked with superficial spots of pigment.[2] These investments or sheaths of the ganglion-globules are, according to Valentin and others, formed of several strata, of which the exterior consists of a thin layer of fine granular corpuscles, the next of elongated cells with nuclei, and the most interior and thickest of concentric lamellæ of very delicate cylindrical filaments. By its sheath, each ganglion-globule is isolated from its neighbours; but by the interchange of filaments passing from one sheath to another, the whole of the globules are held together in one group, and lie, as it were, imbedded in the meshes of a network formed by their investments.

The ganglion-globules, which seem sometimes to lie free in their sheaths, so that they may be extracted from them, consist mainly of a red or reddish-gray granular material, held together by a clear soft gelatinous substance; and from this, the ganglia and the gray parts of the brain and spinal cord chiefly derive their characteristic colour. The true original form is probably spherical, but in different situations, either to adapt themselves to the surrounding parts, or according to some law of development, they are elongated to an oval or ovate form, or are heart-shaped, or kidney-shaped, or angular, or altogether irregular. In general, each globule has but one nucleus with one nucleolus in its wall; but numerous exceptions to this also are found which, as well as the varied forms of the globules, seem connected with their progress in development, and with their particular offices in each part.[3]

D. *General Arrangement of the two Substances in the Nervous Centres.* The plan of arrangement of the fibres in the brain and spinal cord is already described. The gray substance in the central parts of the brain is composed almost entirely of ganglion-globules, which deviate from the general character only in being peculiarly soft, and invested with extremely delicate sheaths. They are collected in small groups in the interstices of the fine vascular network by which the gray matter is everywhere traversed; and the layers, ganglia, and all other forms of gray substance, are due to the different modes in which they are aggregated. On the surface of the cortical substance of the brain, however, another kind of structure is present, and it is found in smaller quantity about other parts of the gray matter: this is a finely granular substance, containing pellucid spherical or oval vesicles, with one or two dark granules in them. In a rather deeper layer, these vesicles, instead of being irregularly scattered through the granular substance, seem each to have appropriated to itself a portion of the latter for an independent covering; and from this condition there seems to be a regular gradation till, in the yet deeper layers of the cortical substance, the vesicles with their granular coverings, are replaced by perfect ganglion-globules with their filamentous sheaths.[1]

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[1] The microscope does not confirm the opinion of E. H. Weber, Bellingeri, and Grainger that some fibres pass straightway to the central substance of the cord; nor that, which Valentin's experiments seem to prove, namely, that some of the fibres of the anterior roots which are sent to extensor muscles go at once to the posterior columns, and some of those of the posterior roots to the anterior column; neither does it afford any illustration of the reflex or associated nervous acts; but the positive results of experiments are in these questions much better evidence than the negative ones of microscopic examination.

[2] The greater part of this account is from Valentin's works.

[3] On all these see Valentin, Henle, and Klencke, in the works already quoted.

In the pure gray substance of the axis of the spinal cord, the ganglion-globules are arranged in the same manner as in the brain. They are continued even below the giving off of the last spinal nerves in a fine cord-like process, which occupies the termination of the canal of the dura mater.[2]

The ganglia, from whatever part of the nervous system they are taken, present one general plan of structure: their chief mass is composed of a congeries of the ganglion-globules, with which nervous fibres are brought into relation and mingled in various ways. Each ganglionic mass is enveloped by a covering of cellular tissue, continuous with, and analogous to, the neurilemma of the nervous cords that enter into it. The strength of this covering is directly proportionate to that of the sheaths of the globules contained within it; and prolongations from the one are closely interwoven with the filaments of the others.

The nervous fibres that enter into the composition of the ganglia are similar in structure to those of the sensitive and motor nerves, except that they are finer and their sheaths more delicate. A portion of the fibres which enter one side of a ganglion separate as soon as they have penetrated its substance, and, after forming a plexus in its interior, unite again into one or more cords, and emerge from the other side in the same manner as they entered. But another portion do not pass thus simply: separating from the plexus in individual fibres, or in fasciculi containing each a very few fibres, they wind about in the interior, and usually near the surface of the ganglion, in the most varied manners. In most cases the plexus of fasciculi occupies the central part of the ganglion, and the fibres and bundles which compose it may be named the *traversing fibres;* the others are, as it were, *spun* round the central parts, and may be called *winding fibres.*[3]

The interspaces between the fibres of both kinds are occupied by the ganglion-globules, which lie variously entwined by small vessels and nervous fibres. The exact manner of their distribution varies in different ganglia: in some the globules are chiefly arranged around the traversing fibres in the centre of the mass; in others they are evenly dispersed throughout, or absent only at the very exterior; in others they are almost all placed at one side. But, however the component parts are arranged, the general plan of construction is in all ganglia the same.

Valentin believes that the winding fibres are those which are about to be distributed in the organs to which they are destined, and that the traversing plexus-forming fibres are those which are as yet far from their destination and which have to pass through other ganglia, in which they also will at last be arranged as winding fibres. There is, he says, no appearance of fibres generated within the ganglia; none are seen leaving them but such as are continued from those which entered them.[4] Whether they be connected with any fibres of a peculiar structure is already considered: it is only necessary to add, that some of the nerves proceeding from ganglia, and having a gray or reddish-gray colour very plainly marked, contain ganglion-globules mixed with their fibres. This is

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[1] See Henle (Allg. Anat. p. 677) and Valentin.

[2] Remak, Burdach, Arnold, &c.

[3] Valentin (Ueber den Verlauf, &c.); Remak (Froriep's N. Notizen, Aug. 1837). Nearly all this account of the gray substance is taken from the writings of the former.

[4] De functionibus nervorum, p. 66. But compare Volkmann, (see p. 35.)

the case in the connecting cords of the human cervical ganglia of the sympathetic, into all of which ganglion-globules extend from the ganglia themselves;[1] such nerves might indeed be truly called ganglia, for they scarcely differ, except in form, from the bodies usually so named.

Development. Schwann's account of the nerve-tube being formed by the coalescing of primary cells, in which the nervous substance is a secondary deposit, is generally received. Henle thinks, however, that the fused cells may form only the central axis of the nervous fibre, that around this the medullary sheath of Purkinje may be developed, and around this the neurilemma, in the same manner as the sheath of the muscular fibre is supposed by Valentin to be formed. Of the ganglion-globules, Schwann believed that they were primary cells enlarged and containing the peculiar granular gray substance. But Henle renders it more probable that those which are called the nuclei of the globules were the primary cells around which the granular substance has been formed; and he points out the different structures found in the several layers of the cortical substance of the brain as a repetition of the forms through which each ganglion-globule passes. He hence suggests that, through life, there may be a constant generation of globules on the surface of the brain, which may gradually move inwards, to replace others that have been destroyed and absorbed in the deeper layers. Of the muscular and nervous fibres, the ganglion-globules, and the hair, Henle makes, from the view which he has taken of their development, a separate class of what he calls *complicate* fibres or cells; of which the common characters are, that the primary cell, or the axis formed of cells, assumes the position of a nucleus, around which a secondary formation is produced and is itself invested by an outer sheath. In the nerve-fibre, for example, the axis is the series of coalesced cells, the cortical portion is the secondary formation, and the neurilemma is the outer sheath, which holds to the axis the same position as a cell-membrane does to a nucleus.

XV. BLOOD-VESSELS.

A. *Arteries.* After a variety of conflicting and unsatisfactory accounts, Henle[2] seems at length to have discerned such structures in the arteries as are adapted to the functions which experiment shows to be performed by them.

His account of their general structure is briefly this: 1st. They have an epithelial lining,[3] consisting of a very thin layer of elliptic or rhombic lamellar cells, which are sometimes elongated into longitudinal spindle-shaped fibres.[4] 2d. There is, immediately external to this, a layer of peculiar tissue, the *striated* or *fenestrated coat*, (corresponding to the *internal coat* of the older anatomists,) consisting of a very thin, rather stiff, and brittle membrane, often perforated by numerous round or oval apertures, and bearing pale, flat, very narrow fibres, which have, for the most part, a longitudinal direction, and give it a peculiar delicately-striated appearance. This coat, which is often morbidly thickened, and, when an artery is contracted, is commonly thrown into longitudinal folds, is produced by a metamorphosis of the epithelium, whose cells as their nuclei disappear, coalesce and form a homogeneous membrane, on which the fibres are afterwards deposited, and which, at last, as the apertures in it enlarge, is completely removed, leaving the fibres free. (See p. 9). 3d. In some arteries there is, next, a coat formed by a single layer of *longitudinal* granular *fibres*, flat, and tolerably wide, analogous to a coat which is much more prominent in the veins. 4th. A coat composed of *circular fibres* (the *middle* or *elastic* coat of most former writers, the *muscular* coat of Hunter), which forms the chief part of the arterial wall, and comprises all that can be torn from it in a transverse direction. Its fibres are flat, clear, and granular, and break with abrupt ends. Each of them is commonly marked along its middle by dots scattered, or regularly arranged in a longitudinal row, or by a narrow streak: these are the remains of elongated nuclei, which have formed as it were, the pattern, according to which the homogeneous membrane in which they lay has broken up into the flat fibres. The streaks formed of the elongated nuclei often branch and anastomose, so as to form that kind of network which has led to this coat being mistaken for elastic tissue; whereas it is, in fact, the proper contractile coat of the artery, and is, in all respects of development, and microscopic structure, similar to the layers of organic muscle in the stomach, &c. 5th. On its exterior there is a coat of genuine elastic tissue (*tissu jaune*, the *elastic coat* of Hunter); this exists, however, only in the larger arteries, and its thickness, in comparison with that of the preceding, diminishes in direct proportion to the size of the artery. The direction of its fibres varies greatly in different arteries.[1] 6th. The *external cellular coat* consisting of common cellular tissue, with longitudinal closely-woven filaments.

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[1] Valentin, (Ueber den Verlauf. tab. vi.) See also, on a similar case in the glosso-pharyngeal nerve, Volkmann, (Ueber die motorische Wirkungen, &c. Müll. Archiv, 1840, p. 488.)

[2] Ueber die Contractilitat der Gefässe, (Casper's Wochenschrift, Mai 28, 1840,) and more fully in his Allg. Anat.

[3] First described by him in his essay, Ueber die Ausbreitung des Epitheliums, (Müller's Archiv, 1838.)

[4] Remak and Reichert (Müller, Arch., 1841, clxxxviii.) hold that these are not the innermost cells of the vessels, but that within these, and in actual contact with the blood, three is a layer of flattened round, and polyhedral cells, with round, yellowish, nuclei and nucleoli. On all these observations by Henle see Reichert's remarks.

The conclusions from these facts which, as already said, are the first of the kind that have accorded with the results of experiment and observation of the functions of the arteries, may be expressed in Hunter's words: "From the account we have given of the substances which compose an artery, we may perceive it has two powers, the one elastic and the other muscular. We see also that the larger arteries are principally endowed with the elastic power, and the smaller with the muscular; that the elastic is always gradually diminishing in the smaller, and the muscular increasing, till, at last, probably, the action of an artery is almost wholly muscular; yet I think it is not to be supposed but that some degree of elasticity is continued to the extremity of an artery."

"The muscular power of an artery acts chiefly in a transverse direction;.... the elastic power exists almost entirely in the external coat; the internal coat must be the seat of the muscular power..... Arteries are the conductors and disposers of the blood.....The elastic (power of reaction) is best fitted for sustaining a force applied to it, (such as the motion of the blood given by the heart), and propelling it along the vessel; the muscular power, most probably, is required to assist in continuing that motion, the force of the heart being partly spent, but certainly was intended to dispose of the blood when arrived at its place of destination."[2]

B. *Veins.* The six coats already mentioned include all that are found in the blood-vessels; and the distinctions of the vessels of the several orders depend on the proportional quantities of these coats present in each. The veins, according to Henle, have, 1st, a lining of epithelium, like that of the arteries; 2d, a striated or fenestrated coat, similar to the second in the arteries; 3d, a longitudinally fibrous coat, analogous to that in the arteries, but, in the large veins formed of several strata, and often morbidly thickened; 4th, a layer, occupying the place of the contractile circular-fibred coat of the arteries, but much thinner than it, and chiefly or entirely composed of fasciculi of cellular tissue, which like that of the skin and dartos may be regarded as contractile; and 5th, the external cellular coat, with longitudinal fasciculi. The true elastic coat is absent.

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[1] See especially Räuschel, (Diss. inaug. de arteriarum et venarum structurâ. Vratisl. 1838;) and Schwann, (Encyclop. Worterb. der med. Wissench. art. Gefässe.)

[2] Treatise on the Blood, &c.

The valves exist in veins of less than a line in diameter, wherever their office is to be fulfilled.[1] They are covered by the epithelium, and consist of tissue like that of fibrous membranes, which, as Hunter observed, proves that they are not duplicatures of the lining membrane. In the larger valves this tissue is mixed with some like that of the striated membrane of the vein.

Very few conclusions can yet be drawn from these facts, respecting the active functions of the veins. Such as they are, however, they might also be quoted from Hunter, who says, that the veins have nearly the same elasticity with the arteries; that their muscular (contractile) power is very considerable; that the former in some degree preserves them in a middle state; and that the latter adapts them to the various circumstances which require their area to be within that state.

c. *Capillaries.* However little the miscroscope may have contributed to the knowledge of the foregoing part of the circulatory system, it has taught all that is known of this, the more important portion of it. It may indeed be regarded as one of its chief honours that it was the means of obtaining the knowledge of the last fact essential to the full proof of the circulation of the blood. Harvey could only prove that the arteries carry blood from the heart, and that the veins bring it back; of the passage from one set of vessels to the other at their distal extremities he knew nothing, and only in the later part of his researches, decided that it was not by the wide channels, which the older writers called *anastomoses*, but probably through a *parenchyma*, in which the blood was infiltrated.[2] The real mode of transit was first proved by Malpighi,[3] in 1661, by a microscopic examination of the circulation in the distended urinary bladder of a frog[4]. His facts were soon confirmed by many others, and especially by Leeuwenhoeck.

Form and arrangement. It was not, however, till long after this time that the general existence of capillaries was admitted; and when it was granted, volumes of hypotheses were written about their arrangement, and their various relations to the parts around them.[5] Of late years the microscope has established the truth in far greater simplicity than the imagination had pictured it; proving that, to whatever part the blood is sent, it either passes directly from arteries to veins (both of very small size) or flows from one to the other through a network of minute canals;[6] that it never, at least in the healthy state, passes from the blood-vessels into any other canals or cavities, or into the tissues around them; and that the only mode of communication between the cavity of the vessels, and any other part of the body, is through the invisibly-minute pores, which exist as well in the walls of the capillaries and small vessels as in all organized tissues.[7]

But, though these facts have cleared the way for truth, they have not afforded a deeper insight into the real nature of those processes in which the contents of the capillaries come into immediate relation with the surrounding parts. Marvellous as are the structures revealed by the beautiful art of injection, one cannot yet trace the particular purposes that are served by any of the numerous varieties of vascular arrangement; from Swammerdam,[1] who first employed it as a means of preparation in 1667, to the present day, it has shown increasing wonders of form, but has scarcely afforded a glimpse of the intimate nature of any process.[2]

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[1] Henle, *l. c.*

[2] Compare his Exerc. de Motu Cordis, p. 56 and p. 60 (edit. 1766), with passages in the Epist. Prim. ad J. Riolanum (p. 105, ej. ed.), and in the Epist. Secund.

[3] Epist. Secunda ad J. Borellum (De Pulmonibus, p. 143), where he describes both capillaries and the circulation in them. The proof by artificial injection seems to have been first obtained by Harvey's friend, George Ent (Apol. pro circul. sang.), but he could not trace the connexion whose existence he had proved.

[4] The frequent mention of these creatures in physiology will prove how well, in recompense for their sufferings, they deserved the honour of a late essay by M. Dumeril, " Sur les découvertes faites dans les sciences par l'étude de l'organisation des grenouilles, (Bull. de l'Acad. de Méd. 1840.)

[5] See especially Haller, (Elementa Physiologiæ, tom. ii.)

[6] Berres calls them, not capillaries, but *intermediate vessels.*

[7] The acute Prochaska was among the first to establish and appreciate the great value of these facts; see his Disq. Anat.-Phys. Organismi Corp. Hum. p. 94, &c.

It will therefore be unnecessary to enter into all the details of the arrangements of the capillaries and small vessels in the several organs and tissues. The general facts are these—that the capillaries compose networks permeating the interspaces of the proper elements of each organ and tissue; that the diameters of their canals, (which are all of nearly equal size in the same part,) vary from $\frac{1}{1000}$ to $\frac{1}{5000}$ of an inch, the most common size being about $\frac{1}{3000}$[3]; that the meshes generally bear a close relation in form to the predominant disposition of the proper elements of the tissue, and are in some parts (as the lungs, the choroid, and some mucous membranes,) even narrower than the vessels around them, but more commonly are three or four times wider; and that, as a general rule, the more active the functions of a part, (especially if it be an organ of secretion,) the closer is its network of capillaries.

2. *Structure.* The capillaries have distinct walls, and are not mere channels drilled in the tissues around them. In some parts they seem to constitute the main tissue, as in the pia mater, which is an irregular vascular network with a few cells scattered in its meshes, and the smallest possible quantity of cellular tissue, the vessels in the pulpy membrane of the cochlea of birds, and, as Mr. Bowman has lately discovered,[4] the corpora Malpighiana; in others they are separable from the soft surrounding tissues, as in the choroid, iris, and retina; and in all parts of which the tissues around them are well distinguished by colour and compactness, the walls of the capillaries are plainly discernible. The only question now is concerning the tissues which compose them.

According to Henle,[5] the finest vessels are composed of a completely structureless membrane, in which no fibres or striæ are ever discernible, but which bears minute oval corpuscles, the persistent nuclei of the cells from which the capillaries are formed; they are placed longitudinally upon the vessels, and are arranged in one, or two, or alternate, rows. This is named the *primary vascular membrane*, because it appears to be the direct product of the primary cell, or cells from which the capillary vessel is formed, and because, in various development, it exists in the vessels of every kind. In vessels of a size just larger than the capillaries, the nuclei of the primary membrane are considerably elongated; and there are added an inner layer of epithelium-cells and an outer layer of pellucid membrane, bearing elongated, transverse cell-nuclei. The latter represents an early stage of the circularly-fibrous coat of the larger arteries. It is from these elongated, longitudinal, and transverse nuclei, that vessels of this size acquire the appearance from which Schwann,[6] and Valentin[7] deduced that they

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[1] See his life by Boerhaave, and a communication to the Royal Society in 1672.

[2] The most beautiful delineations of the minute vessels are those by Mascagni, (Prodromo della grande Anatomia; Berres, (Anat. Microsc. Corp. Hum.;) and Arnold in his recent great work on Anatomy. The differences of arrangement are much less in the capillaries themselves than in the small vessels preceding and following them; it is to these alone that the descriptions which authors give of arborescent, plumose, tufted, and other forms refer.

[3] Krause (Vermischte Beobacht. Müll. Arch. 1837, and Brit. & For. Med. Rev., vol. vi.), says there are some much smaller, not more than from $\frac{1}{10000}$ to $\frac{1}{15000}$, and others varying from $\frac{1}{6000}$ to $\frac{1}{9000}$ in the retina, villi, and organic muscle; but his observations have not been generally confirmed. On the whole, however, there is sufficient evidence that in some parts, such as the brain, there are a few vessels not large enough to transmit the blood-globules, (see Henle, *l. c.* 471; and Wagner, Lehrbuch, p. 186.)

[4] On the Malpighian Bodies, &c., Philosoph. Trans. 1842, and Medical Gazette, September, 1842.

[5] Allg. Anat. 491.

[6] Encyclop. Worterb. art. Gefässe.

[7] Repertorium, bd. ii.

have transverse fibres, and the latter that they possess both elastic and cellular tissue. Dr. Martin Barry, probably in the same structures, discerns compound double-spiral filaments wound spirally around the vessels.[1]

3. *Functions.* The knowledge of the mode of circulation in the capillaries is entirely due to the microscope, but it must be admitted, that except in Dr. Barry's account of their structure, there is no anatomical confirmation of that which other modes of observation have shown, namely, that they and the small arteries and veins are not at all times merely passive tubes, but occasionally exercise a power of regulating the flow of blood through them.

Under ordinary circumstances the blood moves through the systemic capillaries in an even stream, at an average rate of an inch in a minute and a half, and through the pulmonic system, at the rate of about five inches in the same time.[2] But many circumstances influence the diameter of the capillaries, and the motion of the blood in them. Besides the pathological changes which they undergo, the small arteries and capillaries are seen to be contracted by cold,[3] and by warmth to be slightly enlarged; under the influence of certain irritants also, such as capsicum, or an essential oil, they contract, and again, immediately after, dilate;[4] which fully confirms what general observations had made probable, namely, that during life a power is exerted, by which the small vessels, changing their diameter, can control the passage of their contents. And, in like manner, some confirmation has been afforded to the evidence from experiment, that this power is exerted under the influence of the nerves; for an anatomical connection between the latter and the small vessels has been proved by Purkinje, Valentin,[5] Remak,[6] Henle,[7] and others, who have seen fine nervous filaments on the walls of the cerebral and other blood-vessels of less than $\frac{1}{50}$ of an inch in diameter.

M. Poiseuille has greatly added to the knowledge of the current in the capillaries, by watching the *motionless layer* in it. The existence of this layer was observed by Haller, Spallanzani, and others, but its importance was not appreciated by them. From M. Poiseuille's[8] observations, confirmed and extended by E. H. Weber,[9] Gluge,[10] Wagner,[11] and Ascherson[12] (who has seen the same appearance in mammalia,) it appears that the stream of blood flows most rapidly in the axis of the capillary vessel, and that its velocity gradually diminishes towards the circumference, till, in immediate contact with the walls, there is a layer which is perfectly still. The breadth of this layer, which is the simple result of the adhesion of the blood to the walls of the vessels, is usually from $\frac{1}{8}$ to $\frac{1}{10}$ of that of the whole stream, and is the greater the slower the general current is. Its existence and the different relations of the other parts of the stream are discerned by the observation of the blood-corpuscles. The perfect ones commonly occupy the middle of the stream, surrounded by the lymph-corpuscles, which move ten or more times slower than those in the axis stream. These corpuscles again are surrounded by the motionless layer, into which if any globules are forced, they move very slowly, and, if they come near to the wall, remain for a time quite stationary.[1]

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[1] Proceedings of the Royal Society, Jan. 6, 1842.

[2] These calculations were made by Hales, (Staticks, vol. ii.) Those by E. H. Weber and his brother (Müller's Archiv, 1838, p. 450), make the velocity equal to about $1\frac{1}{4}$ inch per minute. In either case the result seems inconsistent with the rate at which poisons and other substances are proved, by the experiments of Hering and Mr. J. Blake, to be carried with the blood; but the length of capillary tube through which each globule has to pass is extremely small, and in the larger tubes the current is much more rapid. Perhaps also the globules move more slowly than the plasma; if so, the conclusions from the microscope must be deceptive.

[3] Schwann and others, confirming Hastings.

[4] See especially Dr. C. J. B. Williams, (Gulstonian Lectures, Med. Gaz. 1841.) Most of the previous observations by Kaltenbrunner, Wedemeyer, Hastings, &c. are nearly valueless, since it is probable that the substances they employed might chemically alter the physical condition of the blood-vessels and the adjacent tissues.

[5] Ueber den Verlauf der Nerven, p. 12.

[6] Obs. anat. et micros. de system. nervosi structurâ.

[7] Allg. Anat. p. 511.

[8] Rech. sur les causes du mouvement du sang dans les vaisseaux capillaires, (Ann. des Sc. Nat. 1836.)

[9] Müller's Archiv, 1837; and Brit. and For. Med. Rev. Vol. IV.

[10] Sur la couche inerte des vaisseaux capillaires, (Ann. des Sc. Nat. Jan. 1839.)

[11] Nachtrage zur vergl. Phys. des Blutes.

[12] Müller's Archiv, 1837, and Brit. and For. Med. Rev. Vol. VI. p. 219. Among many deductions which may be drawn from this fact of the blood being at rest near the walls of the vessels, is that the capillaries do not exercise a *constant* force in propelling it; if they did the part next the wall should move most rapidly.

The fact that the purpose to which the capillaries are habitually subservient is only the passive one of conveying blood close to those parts of the body which either grow or secrete, renders the vascularity or non-vascularity of a tissue a matter of less interest than it used to be; for it is proved that if a part be only able to imbibe the fluid portion of the blood from an adjacent vessel, it nourishes itself as completely, and after the same method, as one whose substance is traversed by numerous capillaries. The extra-vascular tissues, as they are usually called, that is, those in whose substance neither injection nor the microscope has yet revealed any blood-vessels, and which derive their nutritive materials from the blood flowing in adjacent tissues, are the crystalline lens, epidermis, epithelium, and all forms of cuticle, hair, nails, enamel and dentine of teeth, and the analogous structures of feathers, hoofs, &c. To the list of vascular tissues the microscope and the improved art of injecting have added the cornea,[2] the anterior part of the capsule of the lens,[3] the membrane of the aqueous humour,[4] the hyaloid membrane,[5] the articular[6] and other cartilages,[7] the tendons,[8] the elastic tissue,[9] and even the densest bones.

Development. Schwann's account[10] has been already mentioned, and Valentin's[11] is, on the whole, confirmatory of it. But the direct observation of the process is extremely difficult; and Reichert[12] thinks it more probable that the capillaries are developed as the larger vessels of the embryo—those of the *area vasculosa*, for example—are; namely, that cells accumulate in lines or heaps, of which the central cells gradually assume the character of blood-corpuscles, while the peripheral ones, as soon as the blood begins to move through them, unite to form the wall of the blood-vessel. The relations in development which the coats

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[1] It is probable that the local influence of cold in making the still layer wider, and in retarding the stream of blood, is due as much to some physical influence as to the contraction of the vessels, for M. P. could never discern the latter: he therefore refers the retardation to the well-known rule that the quantity of the same fluid transmitted in a given time by a capillary tube is, within certain limits, directly proportioned to its temperature. He has proved also that the influence of cold is not merely local; but that when it is applied to any part, the capillary circulation is slightly retarded in all; perhaps through the reflex influence of the cold upon the heart.

[2] Romer, in Brit. and For. Med. Rev., vol. ii. 235, &c.; Berres, *l. c.*, t. xii. f. 5.

[3] Schroeder van der Kolk, Over choroiditis als oorzaak van Glaucoma, in the Verband. van het Genootschap .... te Amsterdam, 1841.

[4] Schroeder van der Kolk, *l. c.*

[5] Berres (*l. c.* Pl. xiv.); Dalrymple (in Tyrrell on Diseases of the Eye.) The most perfect injection is described by S. Van der Kolk, *l. c.* See, however, for evidence against these injections, Mr. Toynbee's paper in the Philos. Trans. 1841, p. 159, "Researches tending," &c.

[6] Liston, Medico-Chirurgical Trans. v. 23.

[7] Fremery, Müller's Physiologie, i. 283, &c.

[8] J. P. Medical Gazette, 1839.

[9] Berres, Dœllinger, &c. But this is rather doubtful; the vessels were perhaps in the proper contractile coat of the arteries.

[10] See page 8.

[11] Ueber die Entwick. des Muskel- des Nerven- und des Blutgefässsystems, (Müller's Archiv, 1840.)

[12] Müller's Archiv, 1841. Jahresb.

of the larger vessels bear to the primary membrane may be gathered from what is said elsewhere. (See p. 9.) According to Henle, they are briefly these: the epithelium-cells are constantly developed from the subjacent membrane; the fenestrated membrane proceeds from a coalesced layer of epithelium-cells, and is afterwards broken up according to the pattern of the nuclei formed on it; the fibres of the longitudinal fibrous coat are formed from the elongated longitudinal nuclei of the primary membrane; the circular fibrous coat is formed from a cytoblastema divided into flat fibres on the model of nuclei formed in it; and the elastic and fibro-cellular coats are produced as those tissues are in other parts of the body.

XVI. LYMPHATICS AND LACTEALS.

General Structure and Arrangement of the Vessels. The researches of Panizza,[1] confirming those of Cruickshank, Mascagni, Fohmann, and others, have established that in the tissues generally the lymphatic vessels arise from closely-meshed networks which are interspersed among the proper elements of each part, and which, like those of the capillary blood-vessels, vary in the size both of the canals and of the spaces which they enclose. The difficulty, however, of learning the exact size of these canals is even greater than with the blood-vessels, because of the remarkable yielding of their walls.

There are still several organs and tissues in which no lymphatics have been discovered: such are the brain and spinal cord,[2] the bones,[3] the cartilages, the dense tendons, the eye,[4] the placenta, the umbilical cord,[5] and the membranes of the ovum, and all those into which blood-vessels have not been traced.

The structure of the larger lacteals and lymphatics is very similar to that of the veins. They are lined by an epithelium like that in the blood-vessels; next externally to this is a layer of nearly longitudinal fibres of a character intermediate between those of cellular tissue and the granular fibres of the arterial contractile coat; and around this is a layer of fibres of cellular tissue, which have a circular arrangement, and are connected with those of the next adjacent tissue.[6] The minutest lymphatics seem to be destitute of valves; but valves are discernible in those of less than one third of a line in diameter, and have the same structure as those of the veins.[7] The minutest lacteals in the villi consist of a single membrane with elongated cell-nuclei, corresponding to the longitudinal fibrous membrane of the veins, but not lined by epithelium.[8]

2. *Absorbent Glands.* In the lymphatic and lacteal glands, the walls of the large vessels of which they are mainly composed are traversed by a dense network of capillary blood-vessels; a circumstance which affords some confirmation to the belief that something passes by a kind of secretion from the blood to the lymph and chyle in them, by which the latter becomes more charged with fibrin, and by which the development of the corpuscles is forwarded.

The question whether, in man, the lymphatics and small veins anastomose either in the glands or near their origins, still exists. They certainly anastomose in the latter situation in amphibia and fish,[9] but the microscope has added no evidence to that of Fohmann and the others[1] who hold that they similarly communicate in mammals and birds.

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[1] Osservazioni antropo-zootomico-fisiologiche.

[2] Arnold (Icones Anatom. pars i.) gives admirable figures of the lymphatics of the coverings of these organs; the results of his attempts to inject others in their substance were doubtful.

[3] Cruickshank and Brugmanns believed they had injected lymphatics in bone; but their success is doubtful.

[4] Mascagni (Prodromo) describes some in the eye; but he was too apt to regard every thing as a lymphatic.

[5] See Müller's Physiologie, i. p. 250, on Fohmann's supposed injections.

[6] Henle, Allgem. Anat. p. 551.

[7] Valentin, Repertorium, 1837.

[8] Henle, *l. c.*

[9] See especially Hyrtl, Med. Jahrbuch. des Oesterreich. Staates, bd. xxxi.

3. *Villi.* The bodies to which this name should be exclusively applied are seated in the small intestines only, and are peculiarly the organs for the absorption of the chyle. They are delicate vascular processes of the mucous membrane, from a quarter of a line to a line and a half in length,[2] of which about twenty-five are set on every square line of surface.[3] They vary in form according as the vessels they contain are empty or full of chyle: in the former case they are flat, and pointed at their summits; in the latter they are cylindrical or clavate.[4] Into the base of each there enters a single lacteal vessel, which, after passing along the middle, ends either in a blind, slightly swollen extremity, or, as Krause[5] and Valentin[6] think, in a network. In some villi, also, there are two such vessels, which pass along opposite borders and terminate without anastomosing.[7] The walls of each villus are traversed by a very delicate network of blood-vessels formed of from three to five minute arteries, which, after variously dividing and anastomosing, are continued into one or two veins which descend along the villus to the vessels of the submucous tissue.[8] Each villus is farther invested by a very delicate sheath of epithelium, which is frequently, perhaps after each completed digestion, shed.

These facts regarding the structure of the parts of the absorbent system do not at all illustrate their mode of operation. The lacteals have not open orifices in the villi; they probably derive their appearance of terminal apertures from the cells which compose the epithelium over them; they probably, therefore, act by imbibition through their porous walls. But it is to be observed that they do not lie next to the fluid which they absorb; they are covered by a layer of very vascular mucous membrane and by a sheath of epithelium. Valentin[9] was hence led to suggest that since the blood-vessels in a villus hold nearly the same relation to the lacteal as in a secernent gland they do to the extremity of the duct, and since in absorption the material from the intestines must pass by the blood-vessels to enter the lacteal, it is therefore probable that the chyle is not immediately transferred from the intestine to the lacteal, but is, as it were, secreted into it through the medium of the blood-vessels. Mr. Goodsir[10] has since made it very probable that the agents by which the chyle is absorbed are a layer of cells, which are developed each time the act is performed, beneath the covering of the villus, and from which the chyle, after some degree of elaboration, is discharged by their rupture into or immediately around the lacteal vessels.

With regard to the lymphatics of the peripheral network, Dr. Carpenter[11] has made it highly probable that they do not imbibe all fluids indifferently, but that their office is to absorb the nutritious products of the *secondary digestion;* that sort of digestion which, as Dr. Prout says, is carried on in all parts of the body, and by means of which substances are appropriated for nutrition both from the dead and decomposed elements of all the tissues, and from materials deposited in store for reabsorption, as the fat of hybernating animals.

Experiments have rendered it, on the whole, probable that the coats of the larger lymphatics have vital contractility; and their microscopic structure is favorable to this view. Without such a power the motion of fluid in them is

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[1] See Müller's, *l. c.* p. 256. [2] Ibid. *l. c.*

[3] Lieberkuhn, Diss. de Fabricâ et Actione Villorum, 1782.

[4] They present many other forms in animals; but these seem to be the only ones that occur in man.

[5] Vermischte Beobachtungen, (Müller's Archiv, 1837.)

[6] Müller's Archiv, 1839. [7] Henle, Symbolæ ad Anat. villorum.

[8] Lieberkuhn (*l. c.*), Doellinger (De vasis sanguineis quæ villis ineunt).

[9] De functione nervorum, &c. p. 142.

[10] On the Structure of the Villi, &c. Edinb. Philos. Journ., July, 1842; and Br. and For. Med. Rev. Oct. 1842.

[11] Principles of Human Physiology, p. 337.

inexplicable; with it, no other is necessary; for the valves, extending as they do into the minutest branches, must render the whole force of the contraction of each segment efficient to the propulsion of fluid into the segment above it.

XVII. SECERNENT GLANDS.

Many of the general rules of glandular structure laid down by Malpighi[1] and Müller[2] are deduced from microscopic observation, or, at least, they are settled by it, for the objects illustrative of them do not all lie beyond the field of ordinary vision. Of these general rules, the chief are: 1st, That a general unity of plan prevails in the seemingly manifold varieties of glandular structure in the different organs and classes of animals: 2d, That all secretory glands are composed of tubes opening on a free surface and either simple, or variously ramified so as to present in a small solid space a very great extent of surface for secretion: 3d, That, while the excretory end of the gland-duct opens on a free surface, its opposite or secretory end is always closed: 4th, That aggregations of these blind ends of a ramified gland-duct form the *acini* which were long supposed to be the proper agents of secretion: 5th, That there is no open communication between gland-ducts and other vessels, and that the blood-vessels do not open into the ducts or acini, but ramify in a capillary network in their walls and interspaces, and there supply the materials of the secretion.

Recent observations by Henle, Krause, and others, render it very probable that some of these general rules, though true as far as they go, require to be modified or added to. There are organs which may be strictly called glands, yet have not tubes opening constantly on a free surface, but open thus only at particular times, by a kind of dehiscence. Such are the Peyer's and solitary glands of the small intestines, first well described by Böhm,[3] and since by Krause[4] and Henle;[5] and these may be taken as a type of a numerous class of similar bodies which occur constantly, or at particular times, in the substance of all mucous membranes.[6] Böhm described the Peyer's and solitary bodies as simple sacculi beneath the mucous membrane, without external orifices, containing a fluid rendered opaque by a number of minute white granules and cells, and surrounded by what he called a *corona* of tubules, which had no communication with their cavities. Krause, however, believed that he succeeded in injecting some of the sacculi through these tubules; and thus, though by an error, supplied the first step to that which Henle has generalized with other facts of the like kind in the very probable theory, that all the sacculi of this kind are secretory organs, which are closed till the secretion within them is matured, and then, by an absorption or bursting of their finely-membranous walls, open a communication with the surface of the membrane over them, and thus discharge their contents.

If it be admitted that any organ should be regarded as a gland which abstracts materials from the blood, and instead of appropriating them to its own nutrition, discharges them externally, or into some cavity, then, many organs not hitherto regarded as secernent glands may take their place in this class; such as the ovaries, and the so-called vascular glands, which probably elaborate some fluid and add it to the blood in their vessels, or peculiarly alter the blood as it circulates through them. The ovaries, indeed, may be taken as a type of the glands which have not permanently open ducts; for they contain numerous cells, the Graafian vesicles, imbedded in their stroma, which, at the time of conception, bursting through their enveloping membranes, escape into the oviduct, and leave behind them empty sacs. Just so it is also with the Peyer's glands, and all the others of that class; in the place of which we often find fossæ, the remains of the sacculi or vesicles that have recently burst through the mucous membrane, with whose surface their interior thus becomes continuous.

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[1] Epistola de glandularum consimiliumque partium structurâ.

[2] De glandularum structurâ penitiori.

[3] De glandularum intestinalium structurâ penitiori, 1835; see also Brit. and For. Med. Rev. Vol. I. p. 521.

[4] Vermischte Beobachtungen, (Müller's Archiv, 1837.)

[5] Müller's Archiv, 1839, hft. iv. note; and Allg. Anat.

[6] Lehrt, who is quoted by Henle with just praise for his excellent investigations of epithelia, describes numerous glands without ducts in the pharynx and œsophagus, (Des glandes muqueuses, &c. in Journ. Hebdomadaire, 1833, t. 18.) To this class also must be referred the so-called mucous or lenticular glands occasionally met with in the stomach, urinary bladder, &c.

The proper *morphological element* of a gland, then, seems to be a sacculus or vesicle, elaborating within itself or attracting into its cavity the material of secretion, and discharging it through either an occasional or a permanent orifice or duct. These *primary vesicles* (as Henle[1] names them) are probably primary cells more or less metamorphosed. The walls of the smallest among them are formed of a translucent, structureless membrane; those of the largest consist of several layers of elongated nuclei and filaments of cellular tissue, arranged in concentric circles around them, and are sometimes lined by an epithelium. These additions, it is presumed, are effected by the development of nuclei and cells from the primary cell-wall; as in the blood-vessels the epithelium and the striated and fibrous coats are produced from the primary vascular membrane. The structure of the larger permanent gland-ducts also, when any can be separated from the vesicles, is very analogous to that of the blood-vessels, and is perhaps the result of similar phases of development. They consist of an internal layer of epithelium-cells (generally like those of the adjacent membrane), surrounded, first, by a layer of longitudinal fibres similar to those of organic muscle, next by a much thinner, and not always discernible, layer of circular fibres of the same kind, and lastly by a layer of cellular tissue.[2]

According to the mode in which the primary gland-vesicles arrange themselves, three different forms of glands with permanent orifices may, according to Henle,[3] be produced. 1st, The *closed tubular glands*, which are formed of a single elongated vesicle, or in which a number of vesicles may be supposed to have arranged themselves in one line, and then to have all opened into one another by their apposed portions, except the lowest, which has remained closed at one end, and the one nearest the surface which has opened externally. Such are the Lieberkuhnian and tubular glands of the intestines, and the simple tubular glands of the stomach; mere tubes, like single gland-vesicles elongated to different depths, with walls composed of a tube of structureless membrane, opening permanently on the mucous surface, and closed at their opposite ends. Such also, though rendered more complex by the attachment of vesicles along their sides, are the Meibomian glands; and such, elongated and grown tortuous, are the perspiratory and ceruminous glands. 2d, The *aggregated* glands, in which a number of vesicles arranged in groups have become so connected by a kind of fusion of their adjacent walls, that only a small portion of the membrane of each remains, and they form one cavity, with numerous recesses from its inner circumference. Such are all those commonly called mucous glands (as those of the lips, trachea, vagina, &c.); and the tonsils, lachrymal, Brunnian, salivary, mammary, and Cowper's glands, the pancreas and prostate; which differ only in secondary points of structure, such as the arrangement of their excretory

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[1] Allgemeine Anatomie, p. 821, e. s.

[2] *L.c.*, p. 906.

[3] The descriptions of the muscular fibres are drawn chiefly from the gland-ducts of large animals; such as the ureters and bile-ducts of sheep and horses. (See especially Meyer, De musculis in ductibus eff. gland., diss. inaug., Berol. 1837; and in Froriep's N. Notizen Marz 1838; and Henle, Allg. Anat. p. 934.) The same structures are presumed to exist in man rather from analogy and from pathological facts than from actual observation. Tourtual has discovered true muscular fibres in an hypertrophied human ureter, (Muskelfasern im erweiterten Harnleiter, &c., Müller's Archiv, 1840;) but there are no detailed accounts of the muscular coats of other human gland-ducts.

ducts, and the mode in which the *primary lobules* or simplest groups of gland-vesicles are connected together by fibro-cellular tissue, and supplied by blood-vessels. The smallest branches of the gland-ducts sometimes run into the central cavity of the group of vesicles, which thus all open into it: sometimes the groups, or primary lobules, are set upon the extremities or by the sides of the ducts: but whatever secondary arrangement there may be, all have the same essential character of rounded groups of gland-vesicles opening by a common central cavity into minute ducts. 3d, The *reticulated* glands, such as the kidneys and testicles, which consist of tubes of a transparent and structureless homogeneous membrane, the *membrana propria*,[1] probably formed by the elongation and anastomosis of cells, like the blood-vessels, or the Haversian canals in bone, and like them, connected in a network, and seldom or never ending in a cul-de-sac.

Whether the gland be a vesicle which only once or occasionally opens, or one which, perhaps after sundry metamorphoses, has a permanent communication by ducts with the external surface, the mode of secretion seems to be the same. It is, however, still a question (and one which the microscope will not decide,) whether the fluid separated by the vesicles be always already formed in the blood, or whether it be not in some cases elaborated and transformed in them. Probably there is not one rule for all glands. In certain secretions the microscope detects constituents which could not have been separated as such from the blood, namely, globules and corpuscles of different kinds, which indicate that the fluid separated had the character rather of a cytoblastema than of a dead matter.

In those secreted fluids which serve especially or solely for the purification of the blood, and are therefore more peculiarly excretions, such as the bile and the urine, there appear to be, during health, no corpuscles. But in those which after their discharge have to serve some special office in the economy it is very usual to find cells either perfect or in various stages of development. Henle has treated at some length of these *endogenous* cells. It may suffice to say of them, that they sometimes constitute the essential part of the secretion, as in the testicles, where they either become or generate within themselves the seminal filaments or animalcules;[2] the ovaries, where they become the germinal vesicles; the mammary glands, where they are the peculiar milk-corpuscles; the gastric glands, where they contain digestive fluid. In other cases they form an epithelium to line the gland-vesicles and tubules: in others, without any evident purpose, they are discharged from the gland-ducts or fill their extremities in the form of the so-called mucus-corpuscles; in others they appear as globules or cells of fat.

From the preceding account it is plainly not possible to draw a strict line between secretion and nutrition. In both alike the fluid abstracted from the blood may work in itself those changes which are commonly regarded as characteristic of life. Neither can expulsion from the seat of their production be regarded as peculiar to secreted substances; for the elements of many epithelia remain attached only a little longer than the corpuscles of some secretions, and the attachment of some of them is perhaps even shorter, as, for instance, of the epithelium-cells of the stomach in comparison with the animalcule-generating cells of the semen.[3]

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[1] The *basement membrane* of Mr. Bowman, (Cycl. of Anat. *art.* Mucous Membrane,) who suspects that a similar membrane also lies beneath all epithelia.

[2] See some observations illustrative of this by M. Lallemand, in the Comptes Rendus, 1841, and Edin. Med. and Surg. Journ., 1841. See also Martin Barry, *l. c.* and Kolliker Ueb. das Wesen der Saamenthiere, (Fror. N. Notiz. Juli, 1841.)

[3] The whole question of secretion is admirably treated by Mr. Goodsir in his essay "On the ultimate secreting structure," &c., in the Trans. of the Roy. Soc. of Edinburgh; which, unfortunately, did not come under notice till it was published in the Brit. and For. Med. Rev. of the present month.

XVIII. VASCULAR GLANDS.

Under this name may be classed the thymus and thyroid glands, the renal capsules and the spleen, which, as Henle[1] well says, "agree chiefly in this, that both their minute structure and their physiological import are at present totally unknown." It may suffice, therefore, to refer to the chief works in which there are original descriptions of their minute structure.[2]

XIX. ERECTILE TISSUE.

This might perhaps justly have had its place with the description of the organs of circulation, since the only function which it discharges seems to be chiefly due to the peculiar arrangement of its blood-vessels. The parts in which it is found, however, are sufficiently similar in their characters to form a separate class: they are the penis, the clitoris, and, perhaps, the nipples. The first has been so much more examined than the others that the description of its structure is taken as the type of theirs.[3]

Independently of its blood-vessels, the erectile tissue of the penis is composed of a network of cords and bands, which form a multitude of freely-communicating cells, of various shapes. They are chiefly derived from the fibrous envelope of the penis, from which they pass on either side inwards, connecting the septum with the outer sheath. The substance of these cords and bands is traversed by the arteries of the erectile tissue, which usually run very tortuously within them: the spaces or cells between the cords and bands are occupied by the veins. Each cord or band has in its interior an artery of a size proportionate to its own: where one seems to branch, the artery within it also divides, and sends a branch to its division; and where the bands and cords unite, the arteries within them also unite and anastomose. The terminations of the arteries open in an uncertain manner from the cords which contain them into the veins which are placed in the interspaces of the cords and bands, and of which the latter, since they are covered by the lining venous membrane, may be said to form the walls.

These bands and cords which form, as it were, the skeleton of the erectile tissues, are dense structures, composed of several different tissues. From its surface inwards each consists of the following layers: 1st, a portion of the common lining membrane of the venous system, which is here, as elsewhere, in contact with the venous blood; 2d, a mixed layer of elastic and fibro-cellular tissue, which corresponds to the outer wall of the vein or venous space; 3d, a layer of fasciculated fibres, exactly resembling those of organic muscle, and usually

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[1] Allg. Anat. p. 996.

[2] *On all of them,* Berres, (Anat. Micros.;) Müller, (Physiologie, bd. i. and Archiv, 1840, p. 101;) Burdach, (Physiology, bd. v.;) Henle, (Allg. Anat. p. 996:) and Gulliver, (App. to Gerber's General Anat.) *On the spleen:* Giesker, (Splenologie, Zurich, 1835, quoted by Henle;) Müller, (Archiv, 1834;) Valentin, (Uber den Verlauf der Blutgef. in dem Penis, &c. Müller's Archiv, 1838;) Bischoff, (Müller's Archiv, 1838;) Marcus, (Diss. de funct. lienis. 1838;) Bourgery, Sur la structure intime de la rate, (Gazette Médicale, Juin 11, 1842, and Medical Gazette, August, 1842;) and the earlier works of Hewson, Heusinger, Schmidt, and Meckel. *On the renal capsules:* Nagel, (Ueber die Structur der Nebennieren, Müller's Archiv, 1836;) Bergmann, (Diss. de glandulis suprarenalibus, 1839;) Pappenheim, (Vermischte Beobacht. Müller's Archiv, 1840;) and Berres, (Ueber den zarten Bau der Drusen, Oester. Med. Jahr. 1840.) *On the thyroid and thymus glands:* A. Cooper, (The Anatomy of the Thymus-gland;) Berres, (*l. c.* in Oester. Jahrbuch;) Haugsted, (Thymi in homine, &c. quoted by Henle.)

[3] The only two complete descriptions are those of Müller, (Entdeckung der bei der Erection . . . wirksamen Arterien, Archiv, 1835;) and Valentin, (Ueber den Verlauf der Blutgefässe in dem Penis, Müller's Archiv, 1839,) with a subsequent note by Müller.

directed in the longitudinal axis of the penis; 4th, one of bundles of fibres, like those of tendon; 5th, the artery which occupies the middle of the band or cord, and on the other side of which the same succession of layers is usually repeated, though less regularly, because on one side or other of each band there are generally branches given off.[1]

Thus far there is little question as to the structure of the true erectile tissue: the chief doubt is in regard to the mode in which the arteries pour their blood into the veins. Müller believes[2] that they have two distinct modes of termination; that some of them—the nutritive branches—form a common capillary network, which leads in the usual manner to the minute veins; but that, besides these, there are others, which he names *helicine arteries.* These, he says, form branches about a line long and $\frac{1}{100}$ of an inch thick, which usually proceed at right angles from the branches of the arteries within the bands and cords, and hang loose, with blunt and curved or twisted, but not open, extremities in the venous spaces. Through these the blood is, in erection, supposed to be poured into the veins. Valentin,[3] on the other hand, maintains that the appearance of the helicine arteries is artificially produced; that, in cutting across a collection of cellular spaces like those of the corpus cavernosum, many of the bands and cords which bound and traverse them must be divided; and that since each of these contains in its interior a tortuous artery, it must, when cut away from one of its connexions and floated out in water, present the appearance of the end of an artery hanging loosely in a venous space. He believes, therefore, that the minutest branches of the arteries of the penis, after various anastomoses, dilate, penetrate the fibrous tissue in which they are enclosed, and pass into the smallest venous spaces, or (as it may be better expressed, in accordance with Berres' injections,) into a dense network of comparatively large veins, whose diameter is four or five times greater than that of the arteries, and the interspaces between which are formed by the intersecting fibrous bands and cords, in the substance of which the arteries run.

In erection the blood, under nervous excitement, is poured more rapidly into the veins than it can be carried away through them: they are thus slowly distended, but not completely, till by the tension and spasmodic contraction of the ischio-cavernosi and bulbo-cavernosi muscles, all the venous trunks are compressed and the circulation is still more obstructed. The arteries, running in fibrous tissue, are protected from compression, and can therefore continue to carry blood after the passage through the veins has nearly ceased.

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[1] This description is drawn from the corpus cavernosum of the ass; the same structures exist, but are less discernible, in that of man.

[2] And he is, in general, confirmed by Krause, (Vermischte Beobacht, Müll. Archiv, 1837;) Hyrtl, (Oester. Jahr. 1838, bd. xix.;) and Erdl, (Müller's Archiv, 1841.) But see on their observations, Valentin, Repertorium, 1841.

[3] His observations are confirmed by Berres, (Ueber den zarten Bau der Drusen, Oester. Jahrb. bd. xxxi.)

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PART THIRD.

Original Reports and Memoirs.

REPORT ON THE PROGRESS OF ANATOMY AND PHYSIOLOGY IN THE YEAR 1842-3.

By James Paget,
Lecturer on General and Morbid Anatomy and Physiology, and Warden of the Collegiate Establishment, at St. Bartholomew's Hospital.

The general rule followed in this Report is that those works alone are noticed which were published between the first day of October, 1842, and the last of September, 1843. The author does not pretend to give an account of more than those new things which have, in his opinion, been proved or rendered probable in the period and in the department which the report embraces; nor is it pretended, after all the labour that has been bestowed upon it, that the account of these things is absolutely complete. Some works of importance have probably been inaccessible, others may have been overlooked or wrongly estimated; and therefore all those who find herein no notice of their recent physiological labours, have liberty to believe that the omission is the author's fault, not their's.

The arrangement of the subjects which the author has adopted is that of his own lectures; it is the one most convenient to himself, and probably will suit the purposes of as many readers as any other would.

BLOOD.

Concerning the *general constitution* of the blood, MM. Andral and Gavarret, continuing with M. Delafond the observations already made on human blood, have examined that of many domestic animals, and have drawn these conclusions:* 1. In the species examined, the principal constituents of the blood are the same, but the proportions of each vary. 2. The highest natural average quantity of fibrin is in the herbivora, the lowest in the carnivora: the energy of constitution has no constant influence on the increase of the proportion of fibrin. 3. Of the corpuscles the highest average proportions are found in the carnivora, the lowest in the herbivora; and in the same species there is always an increase proportionate to the energy of the constitution; and in sheep, to the improvement of the breed. 4. During the first day after birth the fibrin is in very small quantity; the corpuscles comparatively abundant. 5. During the last periods of gestation, both fibrin and corpuscles fall below the healthy proportion; after parturition they increase to more than that proportion. 6. The fibrin (in the domestic animals as well as in man) is always increased in the inflammatory state: the corpuscles are never directly influenced in it. 7. The water of the blood has its lowest average in the carnivora, its highest in the herbivora. 8. Dropsy does not supervene on alteration of the blood, unless from diminution of albumen; excess of water or decrease of corpuscles will not produce it.

Coagulation. Dr. Polli,† from a long series of experiments on the influence of various gases on the coagulation of the blood, has shown how the discrepancy of previous experiments has depended on inattention to their details. All other conditions being the same, important differences as to time and mode of coagulation result from temporary exposure of the blood to the air, or from air remaining in the vessel, &c. Avoiding all these sources of fallacy, he found that coagulation takes place in pure oxygen or nitrogen, just as in atmospheric air; but that the presence of carbonic acid always impedes coagulation. Carbonic acid is always given off in coagulation; and the greater the freedom with which it can be evolved, the more are the circumstances favorable to coagulation. The more carbonic acid the blood itself contains the slower is the coagulation, and the greater the chance of a buffy coat being formed; and a buffy coat being formed, without froth and over a dark clot, is always a sign of the blood being surcharged with carbonic acid.

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* Annales de Chimie et de Physique, 1842.

† Gazzetta Medica di Milano, Aprile 15, 1843.

Buffy coat. The exact mode of the formation of the buffy coat has been well illustrated by Mr. Wharton Jones,* whose observations on the blood I can in nearly all points confirm. He ascribes it, as Nasse and others did, chiefly to the tendency of the blood-corpuscles to arrange themselves rapidly in rolls (like rolls of coins,) which form a wide-meshed network, (as seen in a single layer under the microscope,) or a kind of spongework when they are kept in mass. In the former case the liquor sanguinis coagulates within the meshes of the rows of the corpuscles, and hence the distinctly mottled aspect of the layer when coagulated as well as when first drawn; in the latter case the spongework formed by the rows of corpuscles contracts and squeezes out the liquor sanguinis, and permits the greater specific gravity of the corpuscles to come into play, so that they sink quickly and the liquor sanguinis floats to the top and coagulates in a distinct layer. In both cases the pale corpuscles remain with the separated liquor sanguinis and are imbedded in its white coagulum.† The attraction for each other by which the corpuscles tend to unite in rolls, is so remarkably increased in the state of the blood in which a buffy coat is formed, that the early or instantaneous occurrence of this arrangement of them, as seen by the microscope in a single drop of blood, affords all the evidence which could be derived from the formation of a buffy coat on a large quantity.

Corpuscles. On the size of the blood-corpuscles, Mr. Gulliver has added to his former copious observations the measurements of those of many more species of mammalia and birds;‡ and on their structure he has adduced,§ from a comparison of the effects of water, acetic and muriatic acids, and other agents upon the blood-corpuscles of mammalia and birds, further evidence for the belief that those of the former do not contain nuclei; or, rather, that although their central may differ from their peripheral matter, the former does not stand in the relation of a nucleus to the latter, except in the blood-corpuscles of embryos. A chief point in the evidence is, that in the corpuscles of birds, small as they are, a nucleus may be demonstrated; and so plainly, that if such an one existed in the mammal's corpuscle, it could not escape notice when similarly searched for. Mr. Wharton Jones‖ also denies the existence of the nucleus in these corpuscles; and shows that the particles which are supposed to be nuclei exposed by the action of acetic acid on the corpuscles of mammalia, are only portions of albumen coagulated by the acid, such as may be produced by adding acid to liquor sanguinis or serum. At the same time it is not to be supposed that the corpuscle is homogeneous throughout; the central substance is evidently different from the peripheral, and Mr. Jones's opinion seems very probable, that the appearance of a nucleus depends on the walls of the corpuscle being thick, consisting of two layers,

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* British and Foreign Medical Review, October, 1842, and Edinburgh Medical and Surgical Journal, October, 1843.

† The tendency of the pale corpuscles to keep with the liquor sanguinis is also shown by Mr. Gulliver, in his observations that fibrin obtained by washing, even when transparent and quite colourless, contains these corpuscles in great numbers. (Lond. and Edinb. Phil. Mag., Aug. 1842.) I have found that films of liquor sanguinis which has coagulated on healthy blood drawn under oil, are composed entirely of pale corpuscles held together like the cells of a tesselated epithelium.

‡ Proceedings of the Zoological Society, Dec., 1842.

§ London and Edinburgh Philosophical Magazine, August, 1842.

‖ *L. c.*

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the outer transparent, colourless, and resisting; the inner softer and less resisting. Between the two, or perhaps in the inner layer, the colouring matter is contained. The existence of a true nucleus in the corpuscles of the lower vertebrata is not by this rendered doubtful; and Mr. Addison* has shown, in the use of *liquor potassæ*, a good method of demonstrating it in the corpuscles of the frog.

Many interesting observations have been made by both Mr. Wharton Jones and Dr. Carpenter, in support of the view that some of the corpuscles of the blood are a kind of "floating gland-cells."† The former believes that the office of the red corpuscles is to convert albumen into fibrin, elaborating it in their interior, and then, after the manner of gland-cells, dissolving and discharging their contents. The latter thinks it more probable that this office of converting the chemical compound into the organizable principle, is discharged by the pale corpuscles, and that the red corpuscles are the chief carriers of oxygen and carbonic acid. The arguments of each may be found in the last October and January numbers of this Journal. Whichever view be most true, it may be received as highly probable, that the corpuscles in the blood are the agents by which, with the aid of the oxygen imbibed in the lungs, the liquid portion is brought into a state fit for the nutrition of the tissues, and that this is their chief purpose.

Mr. Macleod‡ has described the development of the blood-corpuscles in the chick, dividing it into three stages. At first there are no particles in the blood except minute dark spherical granules. These gradually enlarge and become clear in their centres; but when they have arrived at the double of their original size, the central part of each becomes dull and then distinctly granular, while the border becomes defined, smooth, and clear. This completes the first stage, after which, in the second, the central granules disappear as if they had merged into one central clear nucleus, from which the external portion slowly separates, not at one side only, but all round. In this stage the corpuscle remains circular; but it becomes flatter, both on its surfaces and its edges, and a concave furrow forms between its outer border and the border of the nucleus. At the same time also it acquires colour apparently by the accumulation of colouring matter in the space between the nucleus and capsule. In the third stage, the corpuscle assumes the oval shape: first one side of both the cell and the nucleus gradually stretching out, and then the other, so that every part of the corpuscle becomes narrower except the middle. Coincidently with these changes, the furrow around the nucleus disappears, and the sharp edges of the borders are smoothly rounded off.

Mr. Macleod believes that all these changes are effected by a power dwelling in the granules, each of which developes itself into a cell. He has never seen any congregation of granules to form a cell, nor any multiplication of granules within the once-formed nucleus, nor any opening in the centre of the nucleus, nor any escape of corpuscles from it.§

FIBRO-CELLULAR TISSUE.

Dr Todd and Mr. Bowman‖ have thrown doubt on the received opinion concerning the structure of the fibro-cellular tissue. They regard it not as consisting of bundles of parallel filaments of definite size and structure, but as a substance which has a tendency to split up almost *ad infinitum* in the longitudinal direction, and which has a filamentous appearance from streaks and creasings on its surface. [In small hard tendons, such as those of insects, this description may hold; they are compact and nearly homogeneous bands, with scarcely any appearance of a filamentous composition; but in the looser varieties of fibro-cellular tissue I cannot doubt the existence of bundles of distinct filaments.]

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* Transactions of the Provincial Medical and Surgical Association, vol. xi, p. 253.

† See Report, Oct. 1842, p. 12.

‡ London and Edinburgh Monthly Journal of Medical Science, Sept. 1842.

§ On the speedy and abundant development of microscopic vegetables (like those formed in fermenting fluids) in serum, or other albuminous fluids which have been neutralized by weak acids, diluted with water, and then exposed to the atmosphere, see MM. Andral and Gavarret's 'Recherches sur le Développement d'un Végétal microsc. dans les Liquides Albumineux,' read at the Acad. des Sciences, Jan. 30, 1843, in the Gazette Médicale, Févr. 11, 1843. There does not appear any ground for supposing that these vegetables (which are what Liebig supposed to be precipitated globules of albumen,) are, as some seem to think, a product of the blood; they are only formed under the same circumstances as other analogous vegetables are in other fluids exposed to the air.

‖ Physiological Anatomy and Physiology of Man, p. 69.

A few facts concerning the anatomy of tendons may be collected from the long discussions on tenotomy at the Parisian Academy of Medicine.*

MUSCULAR TISSUE.

I have lately found a mode of attachment of the ultimate fibres of muscles to their tendons which has not yet, I think, been made known. It may be distinctly seen in the muscle torn out from the leg of a fly. Each of three tendons, which are planted in the proximal end of the last but one articulation of the leg, runs in a long straight and flat band up the interior of the next superior division of the limb, and receives on each of its edges the broad and somewhat rounded bases of the muscular fibres. These are arranged in a penniform manner, the base of each fibre on one side of the tendon corresponding to the halves of the bases of two adjacent fibres on the opposite side, like the leaflets of the pteris and some other ferns. The fibres are flat, and their extremities, instead of being ensheathed in the tendinous tissue, only adhere to the border of the tendon, and receive on their outer edges one or two finer tendinous filaments, as if for greater fixity.

Dr. Remak† has found that portions of the diaphragm, the heart, and the muscular walls of the larger vessels of many animals of all classes, will continue spontaneously contracting for as many as forty-eight hours after death. He has also pointed out their several modes of contraction, (?) which he distinguishes as creeping, undulating, peristaltic, and serpentine or zig-zag.

Rigor Mortis. An ingenious paper has been published by Ernst Bruecker‡ to prove that the rigor mortis is due to the coagulation of the fibrin which is effused from the blood-vessels in the liquor sanguinis for the nutrition of the tissues, (especially of the muscles,) but which at the time of death has not yet been assimilated. The paper is chiefly important for the numerous analogies which it points out between the coagulation and subsequent changes of the fibrin and the contraction of the muscles; analogies of which Mr. Hunter had already illustrated many, and some of the most important. But the explanation of the rigor mortis is rendered improbable by the observations of Mr. Bowman, which I can fully confirm, and which prove that the muscle is rigid because its fibres, or parts of them, are contracted, and contracted in the same manner as during life. And some examinations which I have made of the rigor mortis in the involuntary muscles, afford equally strong evidence of its being due in them also to the muscular contraction. I believe that *all involuntary muscles* pass into the continued and fixed contraction of the rigor mortis as soon as they cease to be irritable, and to contract under ordinary stimuli. This may be seen distinctly in many arteries, as well as in the digestive canal and urinary bladder; but the best examples are presented in the hearts of recently slain animals, or of men examined soon after apparent death.§ As soon as they cease to be irritable, the walls of all their cavities,

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* Bulletin de l'Acad. Roy. de Médecine, Nov. 1842, Gazette Médicale, and other journals of the same date.

† Müller's Archiv, 1843, Heft ii. ‡ Ib. 1842, Heft iii.

§ Hearts in the state of rigor mortis are those commonly described as affected by concentric hypertrophy. Dr. George Budd proved some years ago that this appearance of an increased thickness of the walls with diminution of the cavities could not be due to disease of the heart; (Medico-Chirurg. Trans., vol. xxi, p. 296;) and I may add to the evidence which he adduced, (and which ought to have been taken as decisive of the question,) that in every instance the hearts of healthy oxen become affected with an extreme degree of *concentric hypertrophy* within an hour after they are slaughtered. I have little doubt also that the hearts of all persons pass into a similar state within a few hours after apparent death; certainly a large majority of the hearts examined within the first

previously flaccid, gradually become firm and hard, draw in towards the base of the heart, and reduce or completely close the cavities. The heart thus rigid has almost exactly the form and other external characters of the heart when actively contracted during life It is evident that this form, produced as it is by a drawing up towards certain fixed points of attachment of the muscular fibres, could not be acquired by the mere coagulation of either blood or liquor sanguinis within the tissue of the heart; and the only difficulty in believing that the rigidity of the heart and other muscles is due to a contraction comparable with that which occurs during more active life, must be from the seeming improbability that any tissue should maintain a vital contraction so long after apparent death as during the continuance of the rigor mortis. This difficulty, however, which would in any circumstances be more apparent than real, is almost removed by the facts already quoted from Remak.

CIRCULATION.

Dr. Marshall Hall,* in a paper on the 'Circulation in the Acardiac Fœtus,' has given proof that the pulsatory movement of the blood may, under certain circumstances, be communicated to the blood in a second set of capillaries. He placed the pectoral fin of an eel in the field of a microscope, and compressed it by the weight of a heavy probe. The movements of the blood in the capillaries became obviously pulsatory, their pulsations being synchronous with the contractions of the ventricle. He adduces this fact in support of the probability that the circulation in the acardiac fœtus is maintained by the force of the heart in the perfect twin fœtus, by which the blood is driven through the capillaries of the placenta into the umbilical vein of the acardiac fœtus, and thence through its venous capillaries into the aorta, and along the umbilical arteries to the placenta again. And the fact is equally important as an additional evidence of the general propagation of the force of the heart through one or even two sets of capillary vessels.

M. Poiseuille's observation of the influence of cold on the capillary circulation is mentioned in the last Report. (p. 44.) He has further shown† that the influence of some other agents is similar in organic and in inorganic capillary tubes. By adding successively acetate of ammonia, nitrate of potash, and alcohol to the blood, he found that the first two accelerated, and the last retarded its flow. They produced the same effects when added to serum which was made to pass through inorganic capillary tubes; as, indeed, might be expected, seeing that in both cases the bulk of the fluid moves, not upon the walls of the tube, but upon the layer of fluid which adheres and remains at rest upon the walls. Applying these results to determine the rate at which blood passes from one jugular vein to the other through the lungs, heart, &c., he found that the passage was made, in horses, in from eighteen to twenty-four seconds, when acetate of ammonia or nitrate of potash was added to the blood, but in from forty to forty-five seconds when alcohol was added.

According to Mr. T. Wharton Jones,‡ the congestion which succeeds to the temporary acceleration of the capillary circulation in an inflamed part, is due to the red blood-corpuscles adhering together (in the manner already described,) and to the walls of the vessels till stagnation occurs; and he has shown that the same arrest of the blood takes place when capillaries are touched with a solution of salt, or when a stream of carbonic acid is directed against those of the frog's lung. From these last facts he suggests with much probability that the stoppage of the circulation in the capillaries when certain salts are added to the blood, and that which takes place in asphyxia, depend on a similar adhesion of the corpuscles. With regard to asphyxia, his observations agree in their tendency with those of

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ten hours have more or less the appearance of being contracted, and many retain the appearance for twenty-four or thirty-six hours. In the majority relaxation and flaccidity return after the first day. But the rules as to time by which the rigor mortis is regulated in both the voluntary and the involuntary muscles have yet to be studied.

* Lond. and Edinb. Monthly Journ. of Med. Sc., June, 1843.

† Memoir presented to the Académie des Sciences, Janvier 9, 1843.

‡ Report, &c. Brit. and For. Med. Rev., Oct. 1842.

Dr. John Reid on the stagnation of the blood, independent of any apparent mechanical hindrance, when nitrogen is inhaled; and the action of carbonic acid in making the corpuscles cohere in rolls and assume the most favorable condition for the formation of a buffy coat, gives additional probability to the observations already quoted from Dr. Polli.

RESPIRATION.

Respiratory Movements. MM. Beau and Maissiat,* have published some investigations in the physiology of respiration. Revising the forgotten opinions of Haller and Boerhaave, they have pointed out the very different characters of the respiratory movements in men, women, and children. They distinguish three types of these movements. 1. The *abdominal;* in which the visible movements are entirely in the abdominal walls, and especially in their anterior part, the ribs being unmoved, except when the body rests on the side. 2. The *inferior costal;* in which the movement takes place chiefly in the lower ribs, from the seventh inclusive downwards; those above the seventh moving very little, and the less, the higher they stand; and the lower end of the sternum ascending, though in a less degree than the ribs expand. 3. The *superior costal;* in which the movement is effected chiefly in the upper ribs, (especially the first,) which are carried upwards and outwards, and carry with them the clavicles and sternum.

In infants, and often to the third year of life, the respiration is of the abdominal type in both sexes. After the third year, the superior costal type is generally observed in girls, and the inferior costal in boys; and after puberty, the difference becomes more striking. Nearly all women breathe with the upper half of the chest, and nearly all men with the lower half and the abdomen. The mode of respiration in women has no connexion with their wearing of stays, but is probably adapted to the little capacity for breathing with the lower part of the chest during pregnancy. The difference is maintained, in general, even in dyspnœa; only, when it is extreme, a person whose natural respiration is according to any one of these types, may exhibit combinations of the movements proper to the others.

The quiet respiration of the rabbit and the cat is abdominal; their excited respiration is abdominal and inferior costal; that of the dog is always inferior costal; that of the horse is abdominal, except in sighing or when *blown,* when it becomes inferior costal, like that of man. These animals were used in experiments in which many of the actions of the respiratory muscles were observed.

On the anatomy of the osseous parts of the respiratory organs, the authors point out that the intercostal spaces are always proportionately widest between those ribs which are most moved in respiration; the superior are the wider in women, the inferior in men. In men, too, there is a remarkable distance between the sixth and seventh ribs, and the seventh and three following it often form a great projection. The articulations of the last two ribs with the spine are very lax, and their anterior ends being free, they follow the movements of the abdominal walls in which they are imbedded; they commonly descend in abdominal inspiration, and ascend in the inferior costal movement. The first rib is peculiarly moveable in women, and those who breathe like them; nearly, or quite immoveable in men and animals which breathe habitually with the lower ribs and abdomen. And herein is the solution of the question of the mobility or immobility of the first rib, as well as of that respecting the relative degrees of freedom of motion in the other ribs; they vary according to the peculiar type of the respiratory movements.

The shortness and early ossification and anchylosis of the first costal cartilage, make the sternum participate much more in the movements of the upper ribs than it does in those of the lower ones; hence, the antero-posterior enlargement of the chest in inspiration is much greater in women than in men. The increase of the intercostal spaces in inspiration is directly proportionate to their natural width; greatest, therefore, above in women, and below in men. In both, the increase is far greater anteriorly than it is posteriorly. In forcible expiration, the width of

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* Archives Générales de Médecine, Décembre, 1842, Mai, Juillet, 1843.

the intercostal spaces may be reduced to considerably less than it is in ordinary expiration.

MM. Beau and Maissiat investigated also at great length the actions of the respiratory muscles, both by feeling and looking at them while in action, and by vivisections of dogs. Their conclusions, so far as the muscles are concerned in respiration, are briefly as follows, and many of them may be confirmed by observation on one's own person. *Intercostals:* In inspiration, they are elongated, and become hard and concave on their outer surface; in quiet expiration, they are moderately shortened, and become less hard and flat; in complex and forcible expiration, they become prominent and very short and hard. They are therefore muscles for forcible expiration, like their analogues, the oblique muscles of the abdomen; their hardness in inspiration is due to their being stretched; but their contraction (except by their elasticity) is only seen in forced expirations or in efforts.

[For many reasons, this conclusion must be considered very doubtful. The experiment on which the authors chiefly found their belief that the intercostals cannot raise the ribs, consisted in cutting through the pectoral muscles and the whole length of the intercostals between the sixth and seventh ribs on both sides: after this was done the lower ribs were still raised in inspiration (as they suppose) by the diaphragm. Perhaps no conclusion ought to be drawn from the results of such mutilation; but M. Debrou (Gazette Médicale, Jan. 3, 1843,) having repeated the experiment, with the addition of cutting the diaphragm from the ribs, and having found that the ribs were still raised in inspiration, maintains that the five lower ribs are thus raised by their intercostal muscles, and that the sixth, from which the intercostals above were cut away, is *pushed* up by the fifth. The following arguments appear to me conclusive in favour of the usually inspiratory action of the intercostals. 1. When the spinal cord is injured below the origins of the phrenic nerves and above those of the intercostal nerves, the ribs are very nearly motionless in respiration, for the intercostal muscles are paralysed though the diaphragm is active. 2. The upper ribs are chiefly moved in the superior costal respiration, though the diaphragm cannot act upon them. 3. The levatores costarum, which can act in inspiration alone, have an arrangement exactly analogous to that of the external intercostal muscles. 4. Whenever the intercostal muscles are affected by diseases in which the pain is increased by muscular contraction, there is an increase of pain in inspiration.] The authors believe also (and with more probability, for whatever be their ordinary action, the intercostals may in extraordinary circumstances, act in either direction,) that in forcible expiration they serve to make the whole walls of the chest rigid and resisting, so that they may not be distended by the eccentric impulse of the lungs, which are compressed on every side, and especially by the diaphragm. *Levatores costarum:* supposed (but improbably) to be not concerned in respiration, but to serve for maintaining the spine erect. *Infra costales:* probably muscles for forcible expiration, like the internal intercostals. (?) *Triangularis sterni:* a muscle of expiration, by drawing together the sternum and the costal cartilages. *Scaleni:* muscles of inspiration, especially in the superior costal type of movements, but chiefly flexors of the head. *Sterno-mastoid:* auxiliary to the scaleni in forcible inspiration. *Trapezius:* its upper border assists in forcible inspiration, its lower border in forcible expiration. *Levator anguli scapulæ:* acts with the upper part of the trapezius in violent inspiration. *Subclavius,* depressor of the clavicle after forcible inspiration. (?) *Latissimus dorsi:* its lower border acts in forcible expiration, as one may find by feeling the posterior wall of the axilla while coughing; at the same time it makes rigid those parts of the walls of the chest and abdomen on which it lies, and it presses in the lower ribs. *Serratus magnus:* acts in forcible inspiration, but chiefly (as was shown in a patient in whom it alone was paralysed,) it serves, by cooperating with the deltoid, in raising the arm. *Serratus posticus superior:* not a respiratory muscle, (?) but an extensor of the neck. *Serratus posticus inferior:* expiratory. *Pectoralis major:* its lower quarter is a muscle of inspiration, its upper three fourths form one of expiration, but it does not act except in dyspnœa. *Pectoralis minor:* its lower half acts habitually (?) as a muscle of inspiration.

As to the action of the diaphragm, the authors believe that it produces, 1. Elongation of the thoracic cavity, especially in the abdominal type of respiration. 2. Increase of the transverse diameter, by elevating and turning outwards the lower ribs, as in the experiment quoted in a preceding note; and this especially in the inferior costal respiration. 3. Occasionally, in infants, the depression of the costal cartilages. The second of these actions of the diaphgram is also described by M. Magendie.* The true mode of action is probably this: when the muscular fibres of the diaphragm contract, its central portion descends, and at the same time traction is exercised on the ribs at the peripheral ends of the fibres; and when the resistance to the descent of the diaphragm is greater than the resistance to an upward motion of the ribs, these are raised by the fibres which are attached to them, and whose direction, even in moderate inspiration, is nearly vertical. And this drawing upwards of the ribs is necessarily converted into a movement upwards and outwards by the limited and peculiar mobility of their attachments to the vertebræ and sternum. The third assigned action, that of the occasional depression of the inferior costal cartilages in children, is more reasonably ascribed by Mr. Alexander Shaw† to this, the most pliant part of the walls of the chest, being pressed in by the atmosphere when the other parts of the chest are expanded to a size which the lungs cannot attain, on account either of disease of their structure, or of obstruction to the free entrance of air through the larynx and trachea.

Structure of the Lungs. Mr. Addison‡ has given an account of the anatomy of the minute air-passages which, while it confirms nearly all that Reisseissen observed, is more complete, and very probably true. In the fœtus the ultimate bronchial subdivisions are tubular; they have a regularly branched arrangement, ramifying symmetrically in all directions, and terminating without anastomoses in closed extremities which are generally situated at the boundaries of the lobules. But when an animal has respired, the entrance of the air into the lungs distends the lobules, and the ultimate bronchial subdivisions undergo a great change. The membrane composing each of them offers only a feeble resistance to the pressure of the air, and is pushed forwards and distended laterally into rounded inflations, forming a series of communicating cells, which meeting on all sides those of the adjoining bronchial subdivisions, are moulded by the mutual pressure into various hexagonal and pentagonal forms These distended passages (something like large beaded tubes) Mr. Addison calls *lobular passages;* and a section of them shows the *oval foramina* leading from cell to cell, which are so conspicuous in a thin layer of inflated and dried lung. The *air-cells,* according to this account, are the inflated parts of the *intralobular* bronchial subdivisions; and those of each lobule form a distinct system, having no communication with those of the adjacent lobules, except in the common trunk from which the intralobular bronchi of each system are derived. The air-cells are from 1-200 to 1-500 of an inch in diameter; and the oval foramina are from 1-60 to 1-150 of an inch or less in diameter. The blood-vessels lie upon each *lobular passage,* and between each two of them.

Capacity of breathing. M. Bourgery's examinations of the structure of the lungs are detailed in vol. XIV, p. 546. They may easily be reconciled with the more probable account of Mr. Addison, from which they chiefly differ in that the minutest branches of the bronchi are described in them as freely anastomosing, so as to form a series of labyrinthic canals; and that the constrictions of the tubes by which they are formed into cells or loculi are said to be due to annular vessels surrounding them. M. Bourgery§ has more recently examined the relations of the varying structure of the lungs in different ages and sexes to their functional capacity. The subjects examined were fifty males and twenty females, and the deductions are as

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* Précis de Physiologie, p. 310.

† London Medical Gazette, Oct. 29, 1841.

‡ Philosophical Transactions, Part ii, 1842. An abstract, from which the above is taken, is in the Trans. of the Prov. Med. and Surg. Association, 1843, vol. xi, p. 281.

§ Paper read at the Académie des Sciences, Janvier 23, 1843; Arch. Gén. de Médecine, Mars, 1843; Gazette Médicale, and other French journals of the same date.

follows: 1. The measure of respiration (that is, I think, the proportion between the quantity of air which can be taken in by a forced inspiration, and the quantity which the lungs just previously contained) is always the greater the more youthful and lean the person is: strength and health do not in this regard compensate for youth. 2. The measure in males is twice as great as in females of the same age. 3. The function is at its highest point in both sexes at thirty years of age—the age which corresponds with the completest development of the aërial capillary plexus, or finest branches of the bronchi. At this age a forced inspiration increases the air in the chest from 2·5 to 4·3 litres in males, and from 1·1 to 2·2 in females. The boy of fifteen inspires two litres, the man of eighty, 1·35. 3. The volume of air necessary for an *ordinary* inspiration increases with advancing age; and this increase exactly represents the diminution of the energy of the pulmonary hematosis. 4. The capacity of the lungs for forcible inspiration increases from infancy to the age of thirty, doubling itself in twenty-three years. After thirty it diminishes one fifth in the first twenty years; one fifth more in the next ten; and nearly one half in the next twenty; and this gradual decrease of capacity for forcible inspiration is true of all persons, although one may have a greater general capacity of respiration than another of the same age. Hence the young person possesses a great capacity of respiration, as it were, in reserve; the old man has little, and is therefore unfit for great exertion.

Exhalation of carbonic acid. MM. Andral and Gavarret* state the following as the results of experiments made in sixty-two persons (thirty-six males and twenty-six females), to determine the quantity of carbonic acid exhaled in breathing: 1. At all ages beyond eight years the exhalation is greater in males than in females. 2. In males it regularly increases in quantity from eight to thirty years of age; from thirty to forty it is stationary or diminishes a little; from forty to fifty the diminution is greater; and from fifty to extreme age it goes on diminishing till it scarcely exceeds the quantity at ten years. 3. The quantity of carbon exhaled in the form of carbonic acid in one hour by males of different ages is as follows;—at eight years, 77·5 grains; at fifteen, 135 grains; at twenty, 176·7 grains; between thirty and forty, 189 grains; between forty and sixty 156 grains; between sixty and eighty, 142 5 grains; and in a man of 102 it was only 91·5 grains. 4. In females the same proportionate increase goes on to the time of puberty, when the quantity abruptly ceases to increase, and remains stationary so long as they continue to menstruate. When, however, menstruation has ceased, the exhalation of carbonic acid begins again to augment; and, then again, in advancing years, decreases as it does in men. Thus before puberty the quantity of carbon exhaled by girls in an hour is ninety-nine grains: and so it continues while the habit of menstruation continues; afterwards, from thirty-eight to forty-nine years of age, it increases to 130 grains; from fifty to sixty again falls to 113 grains; from sixty to eighty is reduced to 105 grains; and in a woman of eighty-two, was only ninety-three grains. 5. In amenorrhea the exhalation is always increased. 6. In pregnancy the exhalation is equal to that which is natural soon after the cessation of menstruation. 6. *Cæteris paribus*, the more robust a person is the more carbonic acid is exhaled; but the differences are not great. 7. The maximum of exhalation was in a strong man of twenty-six, who in an hour exhaled carbonic acid containing 218 5 grains of carbon; the proportionate minimum in a weak man of forty-five, who exhaled in the same time only 139·5 grains. 8. The influences of the weights of persons, of the capacities of their chests, and of the extent of the respiratory movements, are not great.

DIGESTION.

Structure of the teeth. Mr. Lintott† has pointed out the fact of a regular and constant formation of a layer of bone or, probably, of imperfect ivory like what Mr. Nasmyth has called ossified pulp, within the pulp-cavity of the human tooth, after the age of twenty years, independently of any wearing down of the enamel. The layer is thickest at the orifice of the dental cavity, and gradually diminishes as it descends into it till it is lost upon the walls; its thickness increases with advancing age. He remarks also that the part which is by far the most frequent seat of the commencement of decay in the molar teeth is the groove which separates the tubercles of their crowns, and at which the operculæ (according to Mr. Goodsir) meet when the papillary is changed into the capsular stage of development. These grooves are first affected as regularly in the upper as in the lower jaw; as if they were from the first imperfectly developed: [that is, probably, they are liable to the imperfections of parts last formed, such as are often seen in the other *lines of median* or *central fusion.*]

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* Recherches sur la quantité d'Acide Carbonique exhalé par le Poumon.—Paris, 1843.

† On the Structure of the Human Teeth.—Lond. 1843; abstract in the Lancet, June 24, 1843. There are some excellent illustrations of the mode of growth of the teeth, in Mr. A. Shaw's paper "On the effects of rickets upon the growth of the skull," in the Medico-Chirurg. Trans. 1843, vol. xxvi.

Salivary secretion. Dr. Budge* has found that after extirpation of the parotid, submaxillary, and sublingual glands in a dog and a rabbit, the secretion of saliva continued; its characters remained the same, and no function was disturbed. [The experiments add probability to the opinion that the labial, buccal, palatine, and other glands which the experimenter left behind, are salivary glands.]

A case of a kind of metastasis of the salivary secretion is related by Dr. Roelants,† and is interesting in its relation to the general physiology of secretion. A man, eighty-two years old, had an attack of bronchitis, with fever, followed by suppuration around and probably in one of the parotid glands. The abscess was opened, and two months after a large mass of chalk-like substance was discharged. The abscess soon healed, and he recovered his health; but now, whenever he masticates, saliva flows freely from the skin of the cheek and temple of the side formerly diseased. As soon as he begins to eat, the skin becomes very full of blood, and hot; and gradually drop after drop of clear fluid, with all the characters of saliva, collects on its surface, and runs down the cheek and neck, and continues to do so just as long as he continues eating. His health is not disturbed, and the saliva-secreting surface of the skin is natural in its texture.

Anatomy of the pharynx. Professor Mayer of Bonn described some time ago‡ a *bursa pharyngea* in many mammalia. He has since found it several times in men. It lies in a corresponding position to that which it occupies in the mammalia, namely, in the middle line in the mucous membrane covering the body of the sphenoid bone, just behind the posterior border of the vomer. It is sometimes large enough to hold a cherry-stone, and in one case was double. He thinks it probable that in other mammalia, in which the bursa is larger, it may sometimes communicate with the sphenoidal sinuses.§

Functions of the stomach. MM. Sandras and Bouchardat,|| assuming that, in general, dissolved substances are absorbed by the veins of the stomach, while those that are insoluble are taken into the lacteals, believe that they have proved that the chief classes of aliments are thus disposed of: 1. Fibrin, albumen, caseum, gluten, and the gelatinous tissues are dissolved by the aid of hydrochloric acid; [and, probably, of pepsin.] A mixture of six parts of this acid with 10,000 of water they found sufficient to make all these principles swell up into translucent

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* Schmidt's Jahrbucher, Bd. xxxv, Heft 3. Dr. Budge's conclusions on the chemical and other characters of the saliva are confirmatory, so far as they go, of the statements in the essays by Dr. Wright, (Lancet, March 5, 1842, and following numbers;) of which I must regret that those relating to the composition of the saliva were published before the date at which this report commences. Many of them are confirmed also by Lehmann. (Schmidt's Jahrbucher, 1843, No. viii, p. 156.) He however states that he has always found sugar altered by saliva, lactic acid being produced by their contact at 95 deg. Fahr. See also on this subject the review of Schultz, Ueber die Verjungung, &c. in vol. XVI, p. 232.

† Heije's Archief voor Geneeskunde, 1842, St. iv.

‡ Froriep's Notizen, April, 1840.

§ Neue Unters. aus dem Gebiete der Anatomie und Physiologie—Bonn, 1842.

|| L'Expérience, Février 3, 1843, from a paper read before the Académie des Sciences.

masses, and *sometimes* to dissolve them. 2. The starchy and saccharine principles are converted wholly or in part into lactic acid, and in that form are absorbed in the stomach. 3. The fatty matters are insoluble, and pass into the intestines, where they are taken up by the lacteals, and form the greater part of the chyle. The experiments which were performed to confirm these opinions before the reporters to the Institute did not succeed well; but if they had done so it would still be hard to explain how the albumen and fibrin can be formed in the chyle from fatty matter alone. Still that some of the starch of food may be transformed and absorbed in the stomach is confirmed by the experiments of Dr. Percy.* These make it probable, 1, that sugar is formed in the stomach by the digestion of starch or wheat flour, though neither these experiments, nor any others yet performed can afford demonstrative evidence of it; 2, that the dextrin into which the starch is first transformed may be at once absorbed, so as to reduce the quantity of sugar which is formed; and 3, that the sugar which is formed must be quickly further changed or absorbed. The latter is the more probable conclusion, and best accounts for the very small quantity of sugar which is ever found after feeding on starch. Lastly, Dr. Percy suggests, that in the cases in which Dr. McGregor found sugar in the stomachs of those diabetic patients who for several days had had only animal food, it might be formed by the oxydation of the fat which is constantly being absorbed from the body during emaciation.

Composition of the bile. Dr. Kemp,† by careful elementary analysis of the bile of the ox, has corroborated Demarçay's opinion that it is essentially a true chemical compound of an electro-negative body with soda. But he holds that this body is neither the *choleic acid* of Demarçay, since it is not precipitated from the soda by acetic acid, nor the *bilin* of Berzelius, because it is not precipitated from the soda by carbonic acid. He has therefore given it the name of *bilic acid.* It has a peculiar bitter-sweet taste, and in mass resembles a fine resin. It is soluble in every proportion in water. In a subsequent paper‡ he has shown that a much greater difference than is usually imagined is effected in the bile while in the gall-bladder. Bile from the hepatic ducts of an ox was destitute of the bitter taste of cystic bile; its smell also was different. It chiefly consisted of two different electro-negative bodies, separable by alcohol, and each combined with soda.

ABSORPTION.

M. Lacauchie§ describes the intestinal villi as possessing during life a power of alternately retracting and elongating themselves by a kind of vermicular motion, which he believes to be influential in the propulsion of chyle. And his account, so far as these movements are concerned, is confirmed by MM Gruby and Delafond,|| who have observed them in the recently-slain horse, dog, and rabbit. They add that besides the movements of retraction and elongation, the villi are capable of moving laterally in all directions, and that their epithelium-cells bear ciliæ.

Some experiments by Dr. Behr¶ may serve, perhaps, to explain somewhat of that which was supposed to depend on an elective power of absorption possessed by the lymphatics, and certainly have added much to the probability that the force by which the lymph is carried along the lymphatics is that of the contraction of their walls.** It has been long known that the lymphatics will not convey certain

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* "Case of Diabetes," Medical Gazette, April 7, and following numbers, 1843.

† London Medical Gazette, Dec. 16, 1842, and March 3, 1843.

‡ Medical Gazette, May 5, 1843.

§ Paper read at the Académie des Sciences, May 15, 1843, see Comptes Rendus and contemporary journals.

|| Paper read and reported as above, June 5, 1843. MM. Gruby and Delafond assign to the epithelium-cells of the villi nearly the same offices as are, with much more probability, assigned by Mr. Goodsir to the transitory cells developed within the villi.

¶ Henle and Pfeufer's Zeitschrift, für ration. Medicin. Heft i, 1842, and Schmidt's Jahrbucher, Heft iii, 1843.

** See last Report.

substances, especially narcotic poisons, while they do carry others. If, for example, the animal's abdominal aorta be tied so as to stop the circulation in its posterior extremities, and ferrocyanate of potass be inserted in a wound in one of them, it is absorbed and carried into the blood by the lymphatics, and is found again in the urine. But if, under the same circumstances, a narcotic poison is put in the wound the animal is not killed by it; and it was supposed that the lymphatics in this exercised some kind of choice. The results of Dr. Behr's experiments are these: 1. Acetate of strychnine was introduced into a wound in an animal's leg, while the circulation was uninterrupted, and death, with convulsions, &c., occurred in five minutes. 2. Ferrocyanate of potass was introduced into a similar wound, and ten minutes after acetate of strychnine into another wound: in four minutes the animal died of the poison, and the ferrocyanate was found in the urine. 3. The same substances were introduced together into a wound in the leg: the animal died poisoned, and even sooner than before, and the salt was found in the urine. 4. The abdominal aorta was tied below the renal arteries, and when the hind limbs were paralysed the acetate of strychnine was put into a wound in one leg and the ferrocyanate of potass into a wound in the other. After two hours and half there were no signs of poisoning but on killing the animal the salt was found in the urine. 5. The abdominal aorta was tied as in No. 4, and the acetate of strychnine and ferrocyanate of potass were introduced into the same wound The animal showed no signs of poisoning, and the salt could not be found in the urine. This last experiment was several times repeated, and, with unimportant variations, with a constantly similar result. It would follow, therefore, that when the circulation in the blood-vessels is stopped, the lymphatics can absorb and convey to the blood ferrocyanate of potass, but not acetate of strychnine; and that when the two substances are applied to them together it can absorb or carry neither. Hence it is supposed that the force by which the lymphatics convey fluids is that of the contraction of their walls, and that they are paralysed by the direct contact of narcotics, as other involuntary muscles are.

Mr. George Robinson* has related some experiments in evidence that the absorption of blood-vessels depends on a force generated by and proportioned to the velocity of the blood which is moving in them. He compares it to that force with which water or any other fluid traversing a main tube will draw fluid through a side branch, even against the weight of a considerable column. He has often repeated this well-known experiment, and has added proof that the same force will act in the same way through one or more membranes. Having filled a wine-glass with coloured fluid, and having connected its contents, (by means of a bent tube twelve inches long and $\frac{1}{14}$ of an inch in diameter, and having one of its ends covered with membrane,) with the interior of a pipe half an inch in diameter, he found that within five minutes after the stream had begun to flow rapidly through the last-mentioned pipe, the whole of the air present in the smaller tube was absorbed, and its place supplied by the coloured fluid, which had risen from the glass. In another experiment the fluid from the glass was raised through a shorter tube to the membrane, and was made to flow in a slow but constant stream towards the fluid, passing through the larger pipe.

TRANSFORMATIONS OF NUTRITIOUS SUBSTANCES.

Among the numerous papers written on the transformations which the food undergoes in its passage in the body, the most interesting and almost the only ones which afford any definite conclusion are those relating to the formation of fatty matters from the saccharine and starchy principles. It seemed to be proved by Huber's experiments on bees that wax could be formed by them out of pure sugar or honey; for when their food contained nothing but one of these they formed their combs as usual. M. Dumas, who had opposed Liebig's deductions from these facts, suspected that the wax might be formed from the fat which the bees had in their own bodies before they commenced their purely saccharine diet. He therefore,

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* Lancet, May 27, 1843.

with M. Milne Edwards,* repeated the experiment, and in a successful trial obtained the following results: 1988 bees were inclosed in a hive, and from an analysis of the bodies of 117 from the same stock it was estimated that the bodies of the 1988 contained 3·218 grammes of fatty matter. The honey on which they fed contained $\frac{8}{10000}$ of waxy matter. The experiment was continued thirty-one days, and the bees consumed 834·889 gr. of honey, and produced 11·515 gr. of wax, or at the rate of 0·0064 for each bee. After the experiment 105 bees were analysed, and yielded 0·442 gr. of fatty matter, or at the rate of 0 0042 gr. each. Thus the fatty matter preexisting in each bee was 0·0018 gr., and the quantity furnished to each in its food was 0·0038: but each produced in thirty-one days 0·0064 gr., and each at the end contained 0·0042, giving a total of fatty matter 0·0106, and an excess, which must have been formed by transformation of the food, equal to 0 00742 gr. per bee.

The old view of the production of the oleaginous constituents of the bodies of herbivora by the transformation of the saccharine and amylaceous principles of their food is thus confirmed; and the evidence is the better for its being honestly published by one who had been the chief opponent of the view. Connected with it is a fact recently observed by MM Pelouze and Gelis,† that under certain circumstances, butyric acid is formed during the fermentation of sugar. By the action of the acid thus obtained upon glycerin they formed also butyrin, another of the constituents of butter. Still, however, the results of the experiments on which Dumas' former opinion was founded are important, as proving that the several articles of food of the herbivora contain a much larger proportion of fatty matter than had been imagined. In maize and other grains, for example, he has found from 7 to 9 per cent., and in grass, hay, &c. considerable proportions, which in all probability contribute to the formation of the fat, though they are not its only source.

Assimilation. In the last Report‡ some remarkable observations were referred to, proving the analogies between the forms assumed by certain inorganic precipitates such as those of the carbonates of lime and iron, and the forms of the nuclei and cells of organic tissues. Now, Dr. Hermann Jordan,§ of Saarbrück, has called attention to the phenomena of the reparation of damaged crystals, as bearing analogy to the repair of injured organized bodies. The facts which he establishes are these: 1. Any portion of crystal—whatever surfaces, angles, or edges may have been removed from it—may, under proper circumstances, repair itself into a complete individual; that is, restore itself to the same form which it would have had if no injury had been done to it. 2. At the same time with the reproduction of the truncated part, a growth of the whole crystal takes place: *but the effort of the formative act is especially directed to replace the lost part.* 3. The effort at reparation stands in a direct relation to the extent of the loss, and decreases in proportion as the loss is replaced. 4. He points out the mode in which the process of reparation takes place, and concludes that his examinations "have demonstrated the tendency of individuals to maintain their integrity and to replace material losses by the formation of more matter, according to the type of their original form, as a phenomenon to be observed as well in inorganic as in organic nature —as a phenomenon which belongs to the individual as such, whether it have a membered body or the simple structure of a crystal."

ORGANS OF ANIMAL LIFE.

Chemical composition of bone. The following are the results of the most recent and careful analyses of human bone, by Marchand and Lehmann. In both cases the bones were deprived of fat and periosteum : in each the average of six examinations is given; Marchand's* were made on thigh-bones, Lehmann's† on the long bones of the arm and leg.

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* Paper read at the Académie des Sciences, Paris, Sept. 18, in the Comptes Rendus, and contemporary journals. Before the publication of these experiments many controversial papers of much interest had appeared, many of which may be found in the Annales de Chimie et de Physique, and the Annalen der Chimie und Pharmacie, January, April, &c. 1843, as well as in the contemporary numbers of the Gazette Médicale, the Medical Times, the Annals of Chymistry, &c.

† Paper read and reported as above, Juin 12, 1843.

‡ See p. 12.

§ Müller's Archiv, Heft i, 1842.

			Marchand.	Lehmann.
Organic matter	Cartilage insoluble in H.CL.	27·23	33·26	32·56
	,, soluble ,,	5·02		
	Vessels	1·01		
Phosphate of lime			52·26	54·61
Fluate of lime‡			1·	
Carbonate of lime			10·21	9·41
Phosphate of magnesia			1·05	1·07
Soda			0·92	1·11
Hydrochlorate of Soda			0·25	0·38
Oxydes of iron and manganese and loss			1·05	·86
			100·	100·

The following are average relative proportions of organic and earthy matter, collected by Lehmann from his own and the analyses of two other observers.

	Sebastian.	Lehmann.	Frerichs Compact bone.	Spongy bone.
Organic	36·66	32·28	31·2	37·82
Earthy	63·34	67·72	68·8	62·18

All found that the earthy matter increases with age.

In a memoir on ancient and fossil bones, M. Gerardin§ states that the degrees of alteration which buried bones undergo depend almost entirely on the degrees in which the soils are exposed to air and moisture. They always lose more or less of their animal matter; and sometimes, when they lie in a soil traversed by streams of water, it is completely removed: the ammonia proceeding from the part first decomposed saponifies the rest and makes it soluble. In human bones long buried and in fossil bones there is always more subphosphate of lime than in recent bones; in *human bones* long buried the proportion of carbonate of lime is generally diminished, in fossil bones it is increased. In fossil bones also there is always some fluate of lime; in human bones, under whatever circumstances, there is none: it seems to be introduced into fossil bones by infiltration from without, and its presence may be depended on as a sign that a bone is really fossilized.

Structure of bone. Dr. Fleischmann‖ has described the minute structure of *vegetable ivory*, from the fruit of the *manicaria saccifera*, (Gärtner,) a species of palm growing near the coast of Guiana, as being closely analogous to that of bone, at least in regard to the *corpuscles* which it presents. It possesses also, he says, somewhat of the chemical properties of bone. Thin sections exhibit the most beautiful structures, like the bone-corpuscles, except that they are more regular, and lie within regularly-formed cells, of which they appear to be the nuclei. Branches like the calcigerous canals proceed from each corpuscle, but do not give off smaller branches nor extend beyond the wall of the cell; each branch ends within the cell-wall in a bluntly-closed extremity. He believes that there is the same arrangement in true bone; that each corpuscle has, like a nucleus, a distinct cell-wall around it, such as he has figured in a section of bone from a child; that the canals of the corpuscles are unbranched, and that they end within the cell-walls, having only an appearance of anastomosis with the canals in adjacent cells.¶

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* Journal der Prakt. Chemie, Bd. xxvii, p. 83.

† Schmidt's Jahrbucher, 1843, No. vi; see also the Chemist, 1843, Nos. 1, 2, and 3.

‡ See the next paragraph from M. Gerardin, whose analyses confirm those of Mr. G. O. Rees, in denying the presence of fluate of lime in human or any but fossilized bones.

§ Report from the Académie des Sciences, Gazette Médicale, Oct. 15, 1842.

‖ Müller's Archiv, 1843, Heft iii, p. 202.

¶ In these two last opinions he is certainly wrong; the first is in accordance with the

The chapter on 'Bone,' in the 'Physiological Anatomy' of Todd and Bowman, contains by far the best plates yet published of the minute osseous structure. The ultimate structure also is there described, from preparations made by Mr. Tomes, to be granular. The ultimate granules vary in size from 1-6000 to 1-14000 of an inch; they are oval or oblong, and cohere firmly, possibly by the medium of some second substance. In some instances Mr. Tomes has met with a very minute network, which seems adapted to receive them in its interstices; but this, he considers, requires confirmation.

Process of ossification. In the same work is a description of the process of ossification, which is, in several points, new and interesting, (p. 117.) In the vicinity of the point of ossification the nucleated cartilage-cells (which usually are scattered irregularly) arrange themselves in linear series, which run down, as it were, to the ossifying surface. At first the series are small and not regular, but nearer to the ossifying part they form rows of twenty or thirty. The cells in these rows are closely compressed, and their nuclei seem flattened. The lowest rows dip into and rest in deep narrow cups of bone, formed by the osseous transformation of the intercellular substance between the rows, and as ossification advances these cups are converted into closed areolæ or *cancelli*, with extremely thin lamelliform walls. Immediately upon the ossifying surface nuclei, which before were closely compacted, separate considerably from one another by the increase of material within the cells: they also often enlarge and become more transparent. Deeper in the new bone the lamellæ which inclose the cancelli, and which were formed by the ossification of the intercellular substance, are found thicker and more like perfect bone: they include in their substance elongated oval spaces, which, except that they are roughly granular, exactly resemble the ordinary *bone-corpuscles*, and which are evidently the nuclei of the cells of the temporary cartilages. The curvilinear outline of the now ossified cells of these nuclei can often be discerned. Within the cancelli only a few cells can be detected, these cavities (of the cancelli) being chiefly occupied by a quantity of new substance, consisting of granules, and resembling a formative blastema or basis. It thus appears that after the ossification of the intercellular substance, (by which are formed the lamellæ which are the walls of the cancelli,) the rows of cartilage all arrange themselves on the inner surface of these newly-formed cancelli, and are ossified, with the exception of their nuclei, which remain granular, and subsequently form the corpuscles of bone; and that a new substance or blastema appears within the cancelli, from which, probably, vessels are developed, and the further steps in the growth of the bone proceed.

NERVOUS SYSTEM.

Minute structure. Remak* says that on the axes of each of the larger primitive tubes of the abdominal nervous cord of the River Cray Fish (*astacus fluviatilis*), there is, in the recent state, a winding bundle of extremely delicate fibres, occupying one third or one fourth of the whole diameter of the tube. The fibres of this *central fasciculus* are smooth, parallel, without branches or anastomoses, and less than 1-5000 of an inch thick. They may be seen distinctly when the tubuli are injured: some of them often protrude from the broken extremity. They are found, however, only in tubules from 1-60 to 1-30 of a line in diameter; smaller tubules than these either appear translucent or contain a fine granular substance, and none but the smaller tubules, such as these, are found in the nerves and nervous trunks near the abdominal cord. The spaces between the central fasciculi and the walls of the larger tubules are filled by a clear, colourless fluid. The relation of the central fasciculus in the large tubules of the nervous cord to the central substance of ordinary nerves (the *primitive band* of Remak,) is uncertain.

Repair and union of nerves. Dr. Bidder,† of Dorpat, has made several experiments to determine whether nervous filaments of originally different functions can be made to unite. He experimented on the lingual and hypoglossal nerves

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manner in which Henle supposes the corpuscles and their canals to be developed by a deposition within cells, having in each a central cavity (the corpuscle) and interstitial passages or pores (the canals). See his Allgemeine Anatomie, p. 182.

* Müller's Archiv, 1843, Heft iii, p. 197.

† Ib. 1842, Heft i and ii.

of dogs, but the results were inconclusive. They tended, however, to prove that such a union does not take place; for in several of the cases the connected portion of the two trunks were found, on subsequent examination, disparted, and each had united again with that portion of itself from which it had been separated. It was found that a sufficient union for the restoration of function can take place in three or four months, although a portion of a nervous trunk eight lines in length has been completely removed.

Reflex action. Some evidence in favour of the view that the nerves of the excito-motory system form a system distinct from those conveying sensation and volition, is afforded by the investigations of Mr. Newport.* He finds that in the myriapoda the fibres which correspond to the true spinal cord in vertebrata are distinct from those connected with the cephalic ganglia. They form part of the cord in the intervals between the abdominal ganglia, and may be traced from the periphery into the several ganglionic centres, from which they pass backwards along the cord until they arrive at the next ganglion, from which they pass again to the surface of the body. Now there is reason to believe that the ganglia are not sensitive; for the reflex acts, which are repeatedly performed after the removal of the head or destruction of the central ganglia, are performed without any appearance of volition being exercised in them and always in one and the same manner.

Influence of the nervous centres. Professor Volkmann,† one of the most accurate experimenters of modern times, has occupied himself in testing the value of those experiments which are supposed to prove the direct influence of the central nervous organs upon the movement of the viscera.

With regard to the part of the centres on which the movements of the heart depend,—Volkmann shows that in fresh-slain animals the movements of the heart are so completely irregular, even when left to themselves—in one half minute hurried, in the next retarded, then stopping for one or more minutes and then of themselves going on again—that it is impossible to determine the influence of any supposed excitant of the brain or spinal cord. From a great number of experiments, very carefully conducted, no fixed result could be arrived at except this, that the existence of any direct influence exerted on the heart by irritating the nervous centres is as yet altogether doubtful.

He has come to the same conclusion, upon equally good negative evidence, in regard to the effects supposed to be produced on the motions of the stomach and intestines by irritating the brain and cord. He could find no such influence exerted. The motions of the alimentary canal often entirely cease for a long time, and are then of themselves renewed; but when once they have entirely ceased, no irritation of the nervous centres can reproduce them, although it is certain that after the canal ceases to move the nervous centres are still irritable. He peremptorily denies Budge's experiment in which he believed that though the peritoneum of the abdominal walls was left, the intestines moved when the central organs were irritated and ridicules the *active inflation* of the stomach, which Budge supposed to be thus produced. With equal positiveness he denies the truth of Budge's statements respecting the elevation and expansion of the testicle when a part of the cerebellum is irritated. In repeated trials he could produce no such effects as Budge reports, in either the digestive canal or the testes.‡ His conclusion is, "I am far from

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* On the structure, relation, and development of the nervous and circulatory systems .... in the Myriopoda, &c., Transactions of the Royal Society, 1843. See also Br. and For. Med. Review, vol. XVI, p. 160, et seq., in which, in the review of Arnold and M. Hall on the reflex theory, both this and all the other evidence for the *anatomical distinctness* of the excito-motory system are adduced, with the exception of the observations by Van Deen presently to be mentioned. [Since the preceding was in type I have been favoured with the perusal of the further analysis of Mr. Newport's works contained in an earlier part of this Number, to which I must refer as affording a more complete account of them than could be inserted in the text.]

† Müller's Archiv, 1842, Heft v.

‡ The accuracy of several others of Dr. Budge's experiments and deductions is impugned by Dr. Stilling in Haeser's Archiv, 1842, Heft i, and in Schmidt's Jahrbucher, 1843, Heft ii, iii, &c.

denying that the central organs exercise an influence on the motions of the viscera, for pathological observations make that certain. But they do not prove that this influence is a direct one ; and experiments on living or fresh-slain animals prove it still less."

Brain. In a very valuable contribution to the statistics regarding the weights of organs—of which, however, the greater part can as yet serve only to add to the necessary heap of evidence—Dr. John Reid* has made it probable; 1. That the cerebellum does not attain its maximum weight at seven or a few more years of age, though it does attain it sooner than the other organs, and the size of the whole brain, in proportion to the entire body, is greater in the child than in the adult. 2 That the average weight of the cerebellum compared with that of the whole brain, is a little greater in the female than in the male. 3. That though the male brain is on the average heavier than the female, yet in proportion to the weight of the whole body, it is rather less heavy. 4. That the brain does not in emaciation diminish in the same proportion as the rest of the body does.

M. Parchappe† has shown from his measurements and weighings that in regard to *the size of the head:* 1, that of males is to that of females as 16,128 : 15,294 ; 2, it increases gradually to the sixtieth year, chiefly through enlargement of the frontal sinuses, and after that time diminishes; 3, it is in same measure proportioned to the stature. And in regard to the *size of the brain:* 1, that the male is to the female brain, on an average, as 156 : 125, and that in weight they have about the same proportion ; 2, that it increases to the fortieth year, and then decreases to the seventieth ; 3, that it bears some proportion to the stature ; 4, that the intellect is not absolutely proportioned to the size of the brain, but is proportioned to the size of the hemispheres, and especially to the extent of their surfaces.

Dr. George Burrows‡ having repeated the experiments of Dr. Kellie and performed others has shown, in opposition to the opinions commonly entertained, 1st, that the brains of animals bled to death are deprived of their blood, and rendered pale and anæmic ; 2, that the quantity of blood in the head is greatly affected by posture and gravitation ; 3, that in death by apnœa there is intense congestion of the cerebral vessels. And from these facts and from several considerations he deduces that the opinion that the quantity of blood within the cranium is at all times the same is untrue. Admitting that the total contents of the cranium must be at all times nearly the same, the cerebro-spinal fluid is rapidly removable from one site to another, and capable of being altogether removed by absorption ; so that this fluid may be regarded as supplemental to the other contents of the cranium—at one time giving place to the increased quantity of blood, at another making up for the deficiency of blood in the vessels and in the same manner varying according to the actual quantity of nervous substance.

Spinal cord. From Dr. Knox§ we have a description of the spinal arachnoid, maintaining that the account usually given of it and of the absence of any regular communication between its cavity and that of the cerebral ventricles is correct, in opposition to the descriptions of Dr. Sharpey and Mr. Ellis.

Drs. Stilling and Wallach‖ deny the existence of globules in the gray matter of the spinal cord, and say that those which have been held to be globules are fragments of divided nerve-tubes. These tubes of the gray matter they describe as differing from those of the white in being of less diameter, having thinner external walls, and being differently coloured. The course of some of them is longitudinal ; that of others transverse and these are continued into the white substance of the cord, crossing the direction of its fibres, but never uniting with them. The filaments of the roots of the nerves are continuous, not with the white filaments or tubules of the cord, but with these its transverse gray filaments.

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* London and Edinb. Monthly Journal of Med. Science, April, 1843.

† Gazette Médicale, Octobre 8, 1842.

‡ Medical Gazette, April 28, and May 5, 1843.

§ Medical Gazette, June 23, 1843.

‖ This account is taken from an analysis of their work (Untersuchungen über die Textur des Rückenmarks, Leipzic, 1842, 4to,) in the Allgem. Medic. Central-Zeitung, Febr. 22, 1843. I have not had time to see more, since obtaining the original, than that the analysis given of it is generally correct.

In some "Additional experiments on the spinal marrow," Dr. Van Deen* mentions two which he has frequently repeated in the presence of competent judges, to prove that the nervous fibrils of the limbs of the frog do not proceed to the brain, but terminate in the spinal marrow. In the first experiment the whole spinal marrow of a frog is exposed, and *all* the roots of all the nerves which go to the fore-legs and abdomen are cut on both sides; the marrow is then divided a little above the place where the nerves of the fore-legs are cut through, and its divided end being gently raised, a portion of glass or paper is pushed under it; but this is done only for the convenience of the further cutting. If now small portions of the spinal marrow are cut off successively from above downwards with great care and without shaking, no muscular movements are excited in the hind-legs; and the sections may be continued to within a little of the place at which the first lumbar nerve leaves the spinal marrow. It is on cutting this part that one first sees muscular motions in the upper part of the thigh; and as one goes on cutting lower down they ensue in both the hind feet.

In the second experiment all the roots of all the nerves of the hind legs are first cut on both sides of the cord, and a portion of paper being put under the lower end of the cord, pieces of the cord are cut off in succession from below upwards. No signs of pain are induced, nor (even when the animal is beheaded) is any motion of the fore-legs excited, till one comes to that part of the cord from which the undivided roots are given off.

These two experiments prove, says the author, 1st, that the primitive fibrils do *not* pass through the spinal cord to the brain, since if that were the case every division of the cord in the first experiment must produce motion in the hind-legs, and every division in the second must have excited pain or, at least, some motion of the fore-legs; and 2dly, that the spinal marrow is not capable of propagating any irritation communicated to it to a great distance through itself, unless nerves are connected with it.

An interesting case bearing upon the physiology of the several columns of the cord is related by Dr. Webster.† There was complete loss of voluntary motion in the trunk and limbs, with retention of natural sensibility in them, and active reflex movements, in consequence of softening of the whole thickness of the middle part of the cervical portion of the spinal cord. The case is inexplicable in the present state of knowledge, unless we believe that Van Deen's experiments are conclusive which seemed to prove that the gray matter of the cord can, generally speaking, convey centripetal impressions to the brain, but not centrifugal impressions from it, and, besides, suppose that in this case the morbid change of the gray matter was not so complete as wholly to interrupt its functions. There are other cases sufficient to prove that considerable degrees of softening and other changes of structure of the cord may exist without complete loss of function.

Mr. W. F. Barlow‡ has published some good remarks on the influence of the impressions from sudden changes of temperature in producing reflex movements.

Particular nerves. Optic. Professor Erdl§ considers that he has traced the fibres of the optic nerves through the following long course: From the optic tract they diverge and expand in the substance of the thalami, then again converge towards the anterior part of the thalami and unite into a cord distinguished by its white colour, which descends into the corpora albicantia, forms a loop in them, and then turning upwards and forwards ascends through the anterior crura into the body of the fornix. From the fornix the fibres are continued into its posterior crura,

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* Tijdschrift voor Natuurliche Geschiedenis en Physiologie, 1842, vol. ix.

† "Case of paralysis," &c. in the Medico-Chirurg. Trans. 1843, vol. xxvi, p. 1; also Report in the Lancet, Nov. 1843.

‡ Lancet, May 13, 1843.

§ Neue Medic. Zeitung, 1843, No. vii, and Oesterreichische Medic. Wochenschrift, May 25, 1843.

and into the corpora fimbriata, in which they descend into the pes hippocampi on each side, whence again they ascend in the tapetum to the posterior part of the corpus callosum, in which the fibres of the two sides again unite. He describes also the generally admitted fibres passing from one retina to the other through the anterior part of the optic commissure; and he supposes that the peripheral ends of these fibres are connected with those of the fibres whose course is described above, so as to form a kind of closed system or nervous ring.

Third nerve. Dr. Fäsebeck,* of Brunswick, describes a branch of the superior division of the third nerve, which is given off soon after that nerve enters the orbit, passes between the superior and external recti muscles of the eye, and penetrates the external rectus.† He describes also a branch one eighth of a line in thickness, going from the otic ganglion into the spheroidal sinus, another going from it to the vidian, and a third going to the tensor palati muscle.

Facial nerve. It was known that in paralysis of the facial nerve of one side the uvula was commonly drawn to the opposite side, and this was supposed to indicate that the facial is the motor nerve of the palate. Some doubt was thrown upon the conclusion by M. Debrou, who showed that the uvula in many persons was naturally not suspended in the middle line. But this objection has been removed by M. Diday,‡ who has observed a case in which the uvula was drawn to the opposite side while the paralysis of one nerve lasted, but gained its straight position when the paralysis ceased. It seems probable, therefore, that at the junction of the superior petrous branch of the vidian with the facial, branches are sent from (not to) the latter which go to the spheno-palatine ganglion, and thence through the posterior palatine nerves to the soft palate, as Soemmering believed.

Corda tympani. Dr. Guarini§ states that he can demonstrate visibly that the chorda tympani comes off as a distinct branch from the facial nerve, without any communication with the vidian. He gives the following reasons for believing that through the corda tympani the facial has a motor influence on the tongue. His experiments were often repeated before Panizza and others. 1. When the hypoglossal nerve is galvanized the tongue is moved convulsively forwards and backwards and upwards and downwards, but the fibres of the middle portion are quiet. 2. When the trigeminus is galvanized the tongue never moves. 3. When the facial is galvanized the tongue moves quickly upwards and downwards, and there is a kind of vermiform motion of its middle part. The first movement depends on the styloglossi muscles, which have a distinct branch from the facial; the second on the linguales, to which branches can be traced from each corda tympani. 4. After dividing the hypoglossal nerve the movements of the stytoglossus and lingualis alone continue, and these may be excited by galvanizing the facial. But the vermiform motion does not continue after (in the same case) the chorda tympani is destroyed.

Nervus vagus and *nervus accessorius.* Mr. Spence‖ has contributed a fact of great importance to the reconciling of the contrary statements respecting the motor functions of the pharyngeal and inferior laryngeal branches of the vagus nerve. He has traced a filament (distinguished from the rest of the vagus by its white colour,) which, arising from the groove between the olivary and restiform bodies, passes along the course of the vagus trunk, but goes over without joining the superior ganglion, and does not join the vagus trunk till just above the inferior ganglion. At this point of junction it is also joined by the internal branch of the accessorius, and from the junction of the two the pharyngeal branch of the vagus is given off.

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* Müller's Archiv, 1842, Heft v.

† An observation of Retzius, made in 1841, that the sixth nerve supplies the retractor muscle of the eye in birds and mammalia, and the muscle of the nictitating membrane in the former appears not generally known by English physiologists, though it is important in the comparative physiology of the eye.

‡ Gazette Médicale, Dec. 24, 1842.

§ Annali Univ. di Medicina, Maggio, 1842, and Schmidt's Jahrbucher, 1813, Heft iii.

‖ Edinburgh Medical and Surgical Journal, Oct. 1842.

The conjoined white cord then descending with the vagus, seems to pass principally into the recurrent nerve, and probably sends filaments into the œsophageal branches.

Mr. Spence, whose dissections agree nearly with those of Bendz, proposes for the separated white cord of the vagus the name of the motor column of the vagus, (motor *root* would perhaps be better,) and likens its arrangement to that of the motor root of the fifth nerve, passing under the Gasserian ganglion, and joining the trunk beyond it. The pharyngeal branch of the vagus and the recurrent laryngeal being thus given off from the internal branch of the accessorius and from a motor root of the vagus, their purely motor functions are sufficiently accounted for; and the experiments of Dr. John Reid, in which irritation of the roots of the vagus nerve produced movements of the larynx, are explained. It is still, however, not clearly explained why his experiments of irritating the accessorius within the skull did not (as those of M. Longet did,) produce movements of the same organ. It is possible that all the filaments of the nerves were not implicated in the irritation.

A confirmation amounting almost to proof of this view of the influence of the nervus accessorius in the movements of the human larynx, is afforded by the fact, that according to Professor W. Vrolik,* the internal branch of the nervus accessorius in the chimpansé does not join the vagus, but goes at once and separately to the larynx, while the external branch is distributed almost exclusively to the trapezius And other facts confirmatory of the same view are supplied by the experiments of Signor Morganti;† which also tend to show that the external branch of the accessorius contains the fibres which have their origin lowest down on the cord, while the internal branch contains those which arise higher up, just below the vagus, of which the author considers the accessorius to be the anterior root.

Spinal nerves. Mr. Viner Ellis‡ has described minutely the arrangement of the posterior branches of the spinal nerves. Within the extent of the multifidus spinæ muscle, including therefore all the spinal nerves, except the suboccipital and the last two sacral and the coccygeal, all the posterior divisions of the spinal nerves have an external and internal branch. Of the cervical nerves the external branches supply the cervicalis ascendens, transversalis colli, and trachelo mastoid muscles; the internal and larger branches supply the multifidus spinæ, semi- and inter-spinales, and those of the four highest give off cutaneous branches. Of the posterior divisions of the dorsal nerves the internal branches penetrate the multifidus spinæ and semispinalis, and give cutaneous nerves from the six upper; the external branches enter the erector spinæ and levatores costarum, and cutaneous portions spring from about the six lower. In the lumbar nerves the internal branches of the posterior divisions end in the multifidus spinæ, and the external branches, giving cutaneous nerves from the three upper, terminate in the erector spinæ. In the three upper sacral nerves the internal branches enter the multifidus spinæ, the external and larger become cutaneous after uniting by anastomotic arches with each other and with the external branch of the last lumbar and fourth sacral nerves.

Sympathetic nerves. Dr. A. Von Walther§ has made experiments in which (after exposing them from behind) he has divided upon the front of the spine, near the sacrum and close to the aorta, some four or seven filaments passing from one of the trunks of the sympathetic nerve to the ischiatic plexus. (The mode of separation is accurately described.) The nearly constant result was, that after two days the capillary circulation on the operated side became more rapid, the capillaries smaller, and the blood-corpuscles in them disproportionately few. This lasted till about the fifth day; then for a day the circulation became natural, and then it

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* Recherches d'Anatomie Comparée de Chimpansé, p. 40.

† Gazette des Hôpitaux, Août 17, 1843; analysis of an article in the Annali Univ. di Medicina.

‡ Medical Gazette, February 10, 1843. § Müller's Archiv, 1842, Heft v.

became slower and pulsatile, and gradually ceased. The blood-corpuscles accumulated in the larger vessels in spots, exudation took place, and the membrane of the web became soft and rotten.

With one exception in many experiments these changes occurred on only the foot of the injured side; yet, ingenious as they are, there must be much doubt as to the sufficiency of these experiments to prove the influence of these sympathetic nerves upon the irritation of the limb. The mere injury of the other nerves of that side would produce some effect, especially in animals tied down for fourteen or more days.

Dr. Fäsebeck* finds a sublingual ganglion between the mylohoideus muscle and the sublingual gland, about two lines from the lower border of the latter. It is a round, flat, grayish-red swelling, about a line in diameter, and receives branches from the lingual branch of the fifth, from the chorda tympani, and from the filaments of the plexus around the sublingual artery. There proceed from its anterior and inferior part six branches, which penetrate the sublingual gland, and of which one accompanies the duct. He describes also six ganglia, each from one to three lines in diameter, between the lower part of the trachea and œsophagus, and between the latter and the spine, formed on branches of the sympathetic, vagus, and recurrent nerves, and giving filaments to the cardiac plexus, aorta, pulmonary artery, thoracic duct, superior cava, trachea, œsophagus, and pericardium.

SPECIAL SENSES.

Eye. Dr. W. Clay Wallace† has described two new muscles of the eye, to which he has assigned the function of adjusting the focal length of the organ for viewing distant and near objects. They resemble crescents, the horns of which meet at the equator of the eye, and they surround the gray cellular matter connecting the ciliary processes. Their fibres are radiated, and their colour like that of the muscles of the frog's leg. The trunks of the ciliary arteries pass the muscular fibres at the junction of the crescents, and are therefore not affected by their contraction; but the veins pass directly under the muscles and are compressed at each act of contraction. Supposing therefore that the eye is adjusted to a remote object and suddenly directed to a near one, an indistinct image of the latter is formed on the retina. The impression of this image is, Dr. C. Wallace thinks, communicated to the sensorium, and by a reflex impression through the third and fifth (?) nerves the muscles around the ciliary processes are made to contract; the veins of those processes being thus compressed they become erect, and their apices which float in the aqueous humour are elongated; these apices being attached to the anterior wall of the canal of Petit, draw it forward and with it the crystalline lens, till a distinct image of the object is formed on the retina. The return of the crystalline to its place is effected by the relaxation of the muscles, the emptying of the veins, and the elastic retraction of the tissue of the vitreous humour.

The description just given of the muscles is from the eye of the ox: in man they form not two crescents, but an entire ring.

According to Dr. Power,‡ the nervous fibres proceeding from the optic ganglia to the retinæ in the loligo, cross each other's course: those from the back part of the ganglia pass on to the anterior part of the retina, and *vice versâ* the bundles interlacing in the most perfect manner, and like the crossing of the fingers of both hands, passing between one another from one side of the ganglion to the opposite side of the retina. Led by this to the examination of the same nerves in higher animals, he found that a similar arrangement existed in all which he examined; in all, either by interlacement or by a half spiral turn, all the filaments which at its origin are in the upper part of the optic nerve, become near its retinal end inferior, so that the inferior filaments of the retina correspond to superior filaments in the brain.

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* Müller's Archiv, 1842, Heft v. † Medical Gazette, Dec. 16 and 23, 1842.

‡ Dublin Journal of Medical Science, January, 1843.

He believes that this arrangement accounts for erect vision, although the impression of an object on the retina must be reversed. And if the observations be true, it is probably not necessary to look further for the explanation of this controverted question.

GENERATION.

Testicles. Mr. Gulliver* has confirmed R. Wagner's observation, that the general enlargement of the testicles which takes place as the period of procreation approaches is accompanied by enlargement of the individual seminal tubes. During winter he finds that the seminal tubes of birds are tolerably thick and strong; but at the season of procreation semen accumulates in them, and their coats are so distended and attenuated that they are very easily ruptured. The same thinning and enlargement of the tubules occurs in the development of the human testicles at puberty.

An interesting case, proving the sympathy of the vital organs with the testicles, is recorded by Dr. Schlesier.† A healthy man engaged in a fray in the dark, was suddenly heard to shriek out: he fell in convulsions and died in five minutes. On examination the only injury found was the rupture of both the spermatic arteries and veins at the internal rings, produced by the scrotum and testicles having been seized and pulled down by one of those with whom the man was fighting.

Spermatozoa. Facts of much importance in regard to the formation of spermatozoa are furnished by the cases first recorded by Mr. Liston and Mr. Lloyd,‡ and since repeatedly observed, in which these bodies are found in the fluid of common hydrocele of the tunica vaginalis testis, and in encysted hydrocele.

Uterus. In an appendix to his former papers on the nervous system of the uterus, Dr. Lee§ has published a further and very elaborate account of his dissections. The description is not such an one as can be here condensed, but in referring to his original papers, I may be allowed to state, that an examination of the preparations which I have been recently permitted to make, has convinced me that Dr. Lee's account and delineations of them are accurate and complete, and that there can be no reasonable doubt that the structures which he has displayed, are, as he describes them, the nerves and nervous ganglia of the pregnant uterus.

Ovum—its development, discharge, &c. The Report of Mr. T. Wharton Jones 'On the Ovum of Man and the Mammifera,' inserted in the last number of this Journal, is so complete to the time of its publication, that little need be now said on this department of physiology. I shall only state at greater length the conclusions recently arrived at respecting the escape of ova independently of fecundation, and the connexion of this occurrence with menstruation, which Mr. Wharton Jones was obliged to compress within the limits of a postscript. Many of these conclusions have been long held on insufficient grounds: those which may now be deemed established are as follows:‖

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* Proceedings of the Zoological Society, July 26, 1842.

† Casper's Wochenschrift, Oct. 22, 1842.

‡ See their respective papers in the Medico-Chirurgical Transactions, 1843, vol. xxvi.

§ Philosophical Transactions, 1842, part II.

‖ The honour of priority in ascertaining many of the facts in these questions has been disputed both here and in France. Being neither willing nor able to decide in such a case, I shall only refer in one note to all the sources in which the recently-adduced facts themselves and the claims of the several candidates for honour may be found:—Dr. Robt. Lee, Lecture in the Medical Gazette, Nov. 4, 1842; Mr. Girdwood, Lancet, March 4, 1843; letters by various contributors, in the following numbers of the same journal; papers by M. Raciborski and Professor Bischoff, in the Comptes Rendus des Seances de l'Académie des Sciences, the Gazette Médicale and l'Expérience, July and August, 1843; Duverney, in the two last-named journals; Pouchet, in the Gazette Médicale, August 19, 1843, in an analysis of his work called Théorie Positive de la Fécondation des Mammifères.

1. Each act of menstruation is connected with the maturation and discharge of an ovum. Numerous cases in proof of this are related (in addition to those formerly recorded by him, and by MM. Gendrin, Negrier, and others,) by Dr. Robert Lee; others by Mr. Girdwood. M. Raciborski has four times found that ova had been recently discharged from the ovaries of virgins who died at or near the period of menstruation; and Bischoff has also four times found Graafian vesicles, containing effused blood, in girls who had recently menstruated.

This menstrual discharge of an ovum is said by Raciborski and Bischoff to be followed by the formation of a corpus luteum, similar to that which is formed when the ovum is impregnated and developed. [But in this I have no doubt they are mistaken. If it were so, one or more corpora lutea should be found in the ovaries of all who die while the habit of menstruation continues; for the *corpus luteum* which forms when impregnation has taken place, is distinct not only through the pregnancy, but for more—often much more—than a month after delivery. Neither are the cavities which are left after the menstrual discharge of ova, or the processes by which they are closed, at all similar to those found when impregnation has taken place. In many examinations of ovaries I have not yet seen a case in which, without impregnation, anything has been found which could be mistaken for a *corpus luteum* formed after an ovum has been discharged and impregnated.] Mr. Girdwood believes that the cicatrices left after the discharge of menstrual ova may be counted, so as to indicate the number of ova discharged and the number of times of menstruation. [But recently I have examined a case in which a girl of seventeen had not menstruated for four months before her death, but previously had menstruated regularly: the ovaries showed no traces of cicatrices. Probably, therefore, the cicatrices remain for a time distinct, but are gradually obliterated, as they are in the nearly analogous case of the discharge of the Peyer's and solitary glands of the intestines.]

3. The menstruation of women, in so far as the periodical maturation and discharge of ova is concerned, is analogous to the *heat* or *rut* of animals. The phenomena, according to Raciborski, may be most distinctly seen in the sow; but in all the domestic mammalia at their period of heat one or more follicles attain their highest degree of development, project upon the surface of the ovary, and at length burst with hemorrhage into their containing cavities, and this whether copulation have taken place or not. Bischoff also has repeatedly found the same things occur in bitches and rabbits whose uterus and tubes have been extirpated: they have heat, the ova mature and detach themselves and pass into the remaining portion of the tube, but of course cannot be impregnated.

4. The discharge of the ova and their passage along the tubes is independent of impregnation and the passage of the seminal corpuscles. This is evident from the facts already mentioned; and others are furnished by Bischoff. In one experiment he kept a bitch carefully secluded till the period of heat ensued. She then copulated once, and immediately after he extirpated the left uterine horn, ovary, and oviduct. The copulation had lasted a quarter of an hour; and he found that the semen had penetrated to the upper angle of the uterine horn, but not into the tube. He found also five ova in the oviduct more than two inches from its abdominal orifice; a distance sufficiently great to prove that they had not been detached in the copulation. Next day he killed the bitch, and found that spermatozoa had reached about a quarter of an inch in the right tube; he found also five ova in the same tube, and as many *corpora lutea* in the right ovary, but none of the spermatozoa had come in contact with the ova. These cases proved the detachment of ova before copulation. In some others Bischoff found that they were not detached till long after the act. In some he found that they were undetached twenty-four hours after copulation, and that the seminal corpuscles had passed on towards them. In others also he found the independence of the passages of the ova and the semen still more marked; for example, several days after copulation, ova were found fecundated in one tube, but in the other sperma-

tozoa alone, none of the Graafian vesicles in the corresponding ovary being either enlarged or fully developed.*

5. Thus, according to the period of heat at which copulation takes place, will be the place at which the semen meets the ovum. If it be early, the ovum may not escape before the semen reaches the ovary; if late, the ovum may have arrived at the uterus; and probably if it have arrived at the lower or uterine third of the tube before it comes in contact with the semen, impregnation is impossible on account of the changes which the vitellus has already undergone. In women it is in like manner near the period of menstruation that impregnation is most likely to occur. It may take place just before menstruation if the ovum be just mature when the semen reaches the ovary; or some days after, the ovum after its discharge remaining impregnable till the semen reaches it. Or, again, as many analogous circumstances in lower animals prove, an ovum may by the sexual excitement be hurried on to its maturity and discharged; and so, in unusual cases, impregnation may take place at a greater than usual distance from the menstrual period. Still the most common time must be, as common observation shows it is, either during or very near the menstrual period. M. Raciborski has found that in one hundred women there are not more than six or seven in whom this is not the constant rule.

6. All these circumstances prove a closer analogy than was supposed to exist between the discharge of the ova of mammalia and those of the fish, batrachia, and others in which the ova are discharged from the body and impregnated external to it. In all alike the discharge of the ova is an independent act; the differences are in the distances from the ovaries at which the semen is usually brought into contact with it.

Dr. J. E Panck† has published an essay on a case in which he believes that he has made the discovery of the organic connexion between the fallopian tube and the ovary of the human female soon after connexion. A girl, twenty-three years old, was suffocated by carbonic acid five days (it was supposed) after her first conception. There were signs of turgescence about all the uterine and ovarian vessels; the uterus itself was large and vascular, and thickly lined by mucus like a decidua and by ciliary epithelium-cells. On the right side the fallopian tube was turned backwards, and its fringe was expanded over the ovary. They were held together by a fine transparent membrane, which extended over them, over the posterior surface of the uterus and right broad ligament, and a little over the left broad ligament, and was slightly adherent to them all. The left tube and ovary were natural; the right ovary was large and vascular. Directly below the attached fimbriæ there was a cavity in the right ovary, like a distended Graafian vesicle, covered only by serous membrane, about three lines in diameter, and containing a blackish substance like clotted blood. But neither in this nor any where else was an ovum found; so that the evidence of the case is far from complete.

Formation and structure of the membranes, &c. M. Serres,‡ in a paper read

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* These facts bear on the question of the possibility of a woman conceiving by two different men; and I find a recent notice of a case, often referred to, of a negress who having, as it was believed by herself and others, conceived twice in the same night, first by a negro and afterwards by a European, bore twins, of which one was a pure negress the other a mulatto. Dr. Hille, a Dutch military surgeon in Surinam, where the delivery occurred, adds that the children were living in 1841, that they were eight years old, that the black child, which was at first the strongest of the two, remained so, and that the mother had died some time previously, and on examination was found to have normally formed genital organs. (Casper's Wochenschrift, Jan. 28, 1842)

† A full account of the supposed discovery is in Casper's Wochenschrift, Mai 27, 1843.

‡ See the Gazette Médicale and contemporary French journals, Juin et Julliet, 1843. MM. Maignien and Jacquart have since published a case (Gazette Médicale, Novembre 4, 1843,) which confirms, they think, M. Serres' view of the amnios. They found in an early aborted embryo an amniotic vesicle fixed to the chorion by a narrow pedicle, near

before the Institute of France, and in subsequent discussions, has maintained the view of Pockels, that the embryo is outside the amnios to the fifteenth or twentieth day, and that the amnios up to this time is a free vesicle, in which the embryo dips and envelopes itself (exactly as the ovum is supposed to envelope itself in the decidua) in a double sac. He adds, further, his belief that the allantois of the human embryo, having its pedicle immediately in front of the caudal prolongation, and at a distance from that of the umbilical vesicle, cannot be regarded as produced by a retroversion of the intestine, but has its origin in the corpora Wolffiana, whose existence in the human embryo he considers he has fully demonstrated. His view was supported by preparations, but in the discussions which followed the reading of the memoir, MM. Coste and Velpeau maintained each his own previous view of the matter, and said that the preparations did not demonstrate that of M. Serres.

Mr. John Dalrymple* has described and figured the minute vessels of the vitelline membrane and allantois of the chick. Of the vitelline membrane he says that immediately around the remains of the vitelline area are seen on the internal surface of the yelk-sac the commencement of a series of radiating folds, which as they advance dip deeper and deeper into the interior of the sac, and separate more widely from each other. When the vitelline cells are completely removed it is seen that vessels alone constitute the framework of these folds, the large trunks forming their bases, while innumerable lesser branches dip deep into the interior of the sac, inosculating repeatedly, and terminating in a series of very tortuous branches, which fringe the extreme edge of each fold. Numerous simple loops are observed shooting from the sides of the larger trunks; and if we conceive each trunk and every small vessel thickly covered with an aggregated arrangement of vitelline globules or nucleated cells, which conceal the vessels and colour them bright yellow, we shall have a true idea of the appearance of these folds previous to the manipulation necessary to display the injection.

In the allantois Mr. Dalrymple says there is a very minute distribution of equal-sized capillary vessels throughout its inner layer, forming an uniform vascular surface covering the large trunks as well as the interspaces of their divisions; and the anastomoses of the capillaries are so numerous and close that the areas they leave do not exceed the diameter of the vessels themselves. From the similarity of this arrangement of vessels to that found in the lungs of the frog, salamander, &c., he thinks evidence may be adduced for the supposed respiratory function of the allantois.

Mr. F. Renaud,† confirming (as nearly all now do) E. H. Weber's description of the arrangement of the vessels of the placenta, points out as a chief source of fallacy in the examination of these structures, the rapidity with which the villi of the chorion absorb water, and are distended and confused by it.

M. Elsaesser‡ has found in 144 fœtuses either born dead or living only a month, that in fifty-two born dead (of which forty-eight were mature and four immature), the ductus arteriosus, ductus venosus, and foramen ovale were all open forty-eight times. In four (one immature) the for. ovale was closed, the others open.

In ninety-two dying in the first four weeks (of which twenty-two were premature) all the passages were open in fifty-eight. In eighty the foramen ovale was open; in seventy-seven the ductus arteriosus; in sixty-five the ductus venosus.

The most common mode of closure is: 1. The ductus venosus, beginning at

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which was the embryo, rather more than a line in length, free at its cephalic extremity, and adhering to the amnios only by its caudal extremity and the inferior part of its dorsal surface.

* Transactions of the Microscopical Society of London, vol. i, 1842.

† London and Edinburgh Monthly Journal of Medical Science, March, 1843.

‡ Henke's Zeitschrift, t. xlii, and Archives Gén. de Médecine, Juillet, 1843. In a later paper (Henke's Zeitschrift, B. iv., No. 42,) M. Elsaesser has given accurately the lengths and weight of 1000 children born at the full period; but in such a form, that no abstract is possible.

the vena portæ. 2. The ductus arteriosus beginning at the middle. 3. The foramen ovale by the application of its edges. Even later than four weeks any of them may sometimes be found partially open.

LACTATION.

M. Mandl* confirms the view of Henle and others in regard to the perfect milk-corpuscles, proving the existence of an external membranous envelope by rubbing the corpuscles between glasses. The oil-globules are set free, and the torn membranes are unrolled and flattened.

M. Raciborski† has examined the question of the influence of menstruation on the secretion of milk, and has found that it is unimportant. The only difference between the milk of nurses who do, and those who do not menstruate, is that in the former the proportion of cream is rather less in the menstrual period than it is in themselves in the intervals, and than it is generally in non-menstruating nurses.

PHYSICAL HISTORY OF MAN.

Characters of the Egyptian and Negro races. Dr. S. G. Morton‡ has made observations on one hundred crania of ancient Egyptians, obtained at seven sepulchral localities from Memphis in Lower Egypt to Deboud in Nubia. He classes them as 1. *Arcto-Egyptians,* including the purer Caucasian nations, as seen in the Semitic tribes of Western Asia, and the Pelasgic of Southern Europe. 2. Austro-Egyptians, in which the cranium blends the characters of the Hindoo and Southern Arab; which people, the author thinks were ingrafted on the original population of Ethiopia, and thus gave rise to the celebrated Meroite nations of antiquity. 3. Negroloid, in which the osteology of the crania corresponds to the Negro; but the hair, though harsh, is long and smooth, like the present Mulatto grades. 4. Negro.

The lines between these could not be exactly drawn. But in the one hundred skulls there might be reckoned fifty-six Arcto-Egyptians, twenty-eight Austro-Egyptians, six Semetic, seven Negroloid, one Negro, and two doubtful.

He deduces, therefore, 1. That Egypt was originally peopled by the Caucasian race. 2. That the great preponderance of heads like those of the purer Caucasians suggests that the valley of the Nile derived its primitive inhabitants from one of these sources. 3. That the Austral-Egyptian or Meroite communities were in great measure derived from the Indo-Arabian stock; thus pointing to a triple Caucasian source for the origin of the Egyptians, when regarded as *one people* extending from Meroe to the Delta. 4. That the Negro race exists in the catacombs in the mixed or Negroloid character: that even in this modified type their presence is comparatively unfrequent; and that if Negroes, as is more than probable, were numerous in Egypt, their social position was chiefly in ancient times what it now is,§ that of plebeians, servants, and slaves.

Stature. Some very interesting observations on the stature of man have been made by Mr. A. Shaw.‖ He shows that rickets not only produces softening of the bones but arrests growth; and this in the lower extremities much more than the upper, so that the child-like form, characterized by largeness of the head, trunk, and upper extremities is persistent. These three parts are in persons stunted by rickets reduced only by 1-13 of the natural size; but the pelvis and lower extremities are reduced by 1-3. There is, therefore, an *arrest of development* in regard to proportion of form.

This is shown further in that the proportion of size between the cranium and face remains as in childhood; the former being always *proportionally* large, though

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* Anatomie Microscopique, livre ix, and Bulletin de l'Académie Royale de Médecine, 1842, p. 1157.

† Bulletin de l'Académie Royale de Médecine, Juin 15, 1843.

‡ On the Form of the Head, and other Ethnographic Characters of the Ancient Egyptians; in the Proceedings of the American Philosophical Society, Nov. 1842.

§ In America.

‖ Medico-Chirurg. Trans. vol. xxvi, p. 336.

absolutely not so large as in the well-formed adult. The proportions are in the child as 8:1; in the well-formed adult as 6:1; in the rickety adult as $7\frac{1}{13}$:1.

On the other hand, where growth is preternaturally active, as in giants, the lower half of the body is the part which is most increased, and it acquires disproportionate length. And in these, the cranium, though absolutely large, is, relatively to the face, small; e. g., in the skull of O'Byrne, the giant eight feet high, in the museum of the Royal College of Surgeons, the proportion of the size of the head to that of the face is only as five to one.

Varieties of the pelvis. Dr. Knox,* in his "Contributions to Anatomy and Physiology," shows that many or all the national peculiarities of the form of the female pelvis, as well as many of those which are regarded as malformations, are to be regarded as due to the fœtal form of the pelvis being more or less persistent. The fœtal form "is more quadrilateral than oval or rounded, and its antero-posterior diameter is the longest: it has the form, in great measure, of the pelvis of the quadruped and quadrumanous mammal, of the human male generally, and of certain ill-formed human female pelves." When the persistence in this form exists on one side only of the pelvis, it produces the *pelvis obliquè ovata* of Naegele. Its more common effect when existing on both sides is to produce the not unfrequent narrow quadrilateral form of female pelvis; but when it exists in an extreme degree on both sides, it may produce, as in a pelvis in Dr. Outrepont's collection, a kind of a double Naegele's oblique pelvis—one with a very long conjugate diameter, but very narrow in front—almost like a seal's pelvis.

He gives cases also of relaxation of the ligaments of the symphysis pubis in delivery.

Age of puberty in girls. Mr. Roberton† of Manchester, in continuation of some former papers, the object of which was to prove that the age of puberty is as early in the cold as in the tropical regions of the earth, and that the early fecundity in Hindostan and other warm countries is only the consequence of early marriages, proceeds now to show, that in all countries alike, early marriages (and early fecundity) are always connected with moral and political degradation, as exhibited in bad laws and customs, the enslavement more or less of the women, ignorance of letters, impure and debasing systems of religion; and that they bear no relation to the climate of the country.

His evidence is extensive and very interesting; and the conclusions he arrives at are, 1. That in England, Germany, and Protestant Europe in general, early marriage, i. e. marriage about the age of puberty, is comparatively rare. 2. That early marriage prevails among the uncivilized tribes within the arctic circle, as it likewise does in *all* cold countries, the inhabitants of which are in a state of ignorance and moral degradation. 3. That throughout European Russia, which is confessedly low in civilization, extremely premature marriage was the universal custom at no distant date. 4. That at the present day, in the most southerly countries of Europe, where the people are immersed in superstition and ignorance, marriage is early. 5. That in Ireland, which as to its moral condition somewhat resembles the last-mentioned countries, the marriage union takes place among the Roman Catholic population almost as early. 6. That in England, about two centuries ago, when debasing political and social circumstances combined to favour the practice, early marriages were general, at all events in the upper ranks. 7. That in all the countries to which reference has been made, juvenile marriage is invariably seen as an attendant upon ignorance and moral debasement, and this without reference to *climate.* 8 That consequently it is allowable to infer that early marriage in oriental countries (which has generally, but without any proof, been ascribed to precocious puberty,) depends solely on the same moral and political causes as produce it elsewhere; more especially as those very causes are well known to exist at present in an aggravated degree in all oriental and intertropical countries.

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* Medical Gazette, July 21 and following numbers, 1843.

† Edinburgh Medical and Surgical Journal, Oct. 1832 and July 1842.

These conclusions are probably in a great measure true; yet that the commencement of menstruation and of fecundity does bear some relation to the latitude and average temperature, appears to be proved by the following table, in which M. Raciborski gives his results as to the average age at which menstruation commences in different countries and towns :

Name of Town.	Latitude.	Age at first menstruation.	Mid. Temp. of the year.	No. of Observations.	Observer.
[*]Toulon	43°	14·081	15·°	43	Marc d'Espéne.
[†]Marseilles	43	14·015	15·	25	Ditto
[†]Lyons	46	14·492	11·6	160	Bouchacourt.
Paris	49	14·465	10·6	200	Raciborski.
Göttingen	52	16·038	8·	137	Osiander.
Warsaw	52	15·083	9·2	100	Lebrun.
[‡]Manchester	53	15·191	9·6	450	Roberton.
Skeen	59	15·450	6·	100	Faye.
Stockholm	59	15·590	5·7	102	Wistrand.
[§]Swedish Lapland	65	18·	4·		Wretholm.

In general, therefore, the period of puberty is later in nearly the same ratio as the latitude is higher: for each degree of the one the other is retarded about a month and a few days. And the lower the latitude, the more frequent are the examples of precocious appearance of menstruation.

A still more exact relation is between the date of first menstruation and the mean year's temperature; as may be seen by comparing Warsaw and Göttingen, Göttingen and Manchester, &c. M. Raciborski adds that *race* often determines the period of first menstruation. The children of negroes born in England menstruate as early as their parents; those of Europeans born in India as late as their parents. To determine how far circumstances of climate could countervail the influence of race, M. Raciborski obtained information respecting the period of menstruation in Jewesses in Poland, from M. Lebrun, médecin-en-chef of a hospital in Warsaw, and found the mean period in Catholics 15·83, in Jewesses 15·89; (100 observations of each race;) showing that the influence of race remained after ten or more centuries. And in like manner the menstruation ceases sooner in Polish Jewesses than in Sclavonian women, lasting in the former on an average $29\frac{28}{33}$ years, and in the latter $31\frac{6}{33}$ years.

There is a difference also, dependent, probably, on numerous causes, between the women of Paris and those of villages a league and half or two leagues from Paris, though both have a similar soil, temperature, &c. In the villages the average age at first menstruating is 15·020 years, in Paris 14 465.[||]

M. Raciborski[¶] has also published an account of the age at which menstruation ceases. At Lyons the average age is between 45 and 50; at the Slp êtrière, in 100 women, the average was 46·03: at Warsaw, 47·05; at Christiana, 48·07. As a general rule, the greater the number of children borne, the longer is the continuation of menstruation; and the earlier the commencement of menstruation, the greater the number of children and the later the cessation.

Changes in age—Varia. A remarkable example of vigour in most advanced age has been observed in M. Rochard, a musician, 107 years old, on whom Mr. Cæsar Hawkins successfully operated for strangulated hernia.[**] The hernia had

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[*] Archiv. Gén. de Méd. 1835.

[†] Dict. des Sc. Méd. 2me edit. 'Menstruation.'

[‡] Edinb. Med. and Surg. Journ. Oct. 1832.

[§] Eighteen years is only a general statement, it should probably be less.

[||] A. Raciborski 'De l'Epoque de la Pubèrté,' &c., L'Expérience, Juillet 26, 1843, and many subsequent numbers. Numerous facts bearing on this and similar questions may be found in Brierre de Boismont, 'De la Menstruation,' &c., Paris, 1842, reviewed in vol. XIV, Oct. 1842.

[¶] Medical Gazette, Dec. 9, 1842.

[**] L'Expérience, Octobre 26, 1843.

been strangulated upwards of thirty hours: the wound united by the first intention, except where two ligatures hung out, and in a fortnight after the operation the old man was as well as before it. He has since died.

M. Ruelle,* of Cambrai, has recorded an example of precocious virility. A child, three years and a quarter old, muscular and strong as one of eight, has all his male organs of the full adult size, with long black hair on the pubes, and under excitement discharges semen four or five times daily. He has also a full male voice, and dark short hair on the cheek and upper lip.

A contribution to the knowledge of the effects of the air at great heights in the atmosphere, and a confirmation of most of the results which have been already obtained are furnished in the observations made in an account of an ascent of the 'Grosse Venediger,' a mountain upwards of 11,000 Austrian feet high, in the southern border of Oberpinzgau, by Dr. F. Spitaler.† The party ascending consisted of forty persons, of whom twenty six only accomplished the feat. The chief effects produced were, 1. On the respiration, which in all became rapid and difficult, and was greatly hurried in exertion, and in some amounted to agony, so that from mere dyspnœa they were compelled to return: one also had slight hemoptysis. 2 On the pulse, which became small and weak. 3 On the secretion of urine, which was remarkably diminished, so that among the whole forty persons, during between eight and nine hours' walking in a temperature only just above freezing point, urine was passed only nine times. 4. On the cutaneous exhalation, which (though the invisible evaporation was probably much increased,) did not once appear as sweat. 5. On the heat of the body. All had the sensation of intolerable cold, though actively exerting themselves and well clothed, and though the temperature was 4° or 5° R, and the weather nearly calm. This was felt, however, only when they had ascended above 9000 feet: below it, although the temperature was not higher, the sensation of cold was far less painful. 6. On the muscular power, which was, in all the party after they had nearly attained the height of 1000 feet, exceedingly prostrated. Some were from utter fatigue obliged to give in; some could not even stand, and of those who went on none could walk more than twenty or, at last, more than ten steps without stopping to rest. In some these signs were accompanied by ringing in the ears, in some by nausea and even by vomiting, in some by utter carelessness of life; not one reached the summit except in a state of complete exhaustion. And all this was far from being the kind of fatigue consequent on extraordinary muscular exertion; for several of those who could not attain the summit and of those who did so only with difficulty descended in good plight and walked on for many hours with scarcely a complaint of weariness.

The influence of the increased brightness of the sun's light was very marked. The clear, deep blue of the most beautiful southern sky was far surpassed in beauty; and though all the party wore dark shades or veils, all suffered from pain and inflammation of the face and eyes and of every part which was at all exposed to the action of the sun

Dr. D. D. Owen‡ has given a detailed account of the impressions of two human feet found on the surface of a slab of limestone, from the specimen described by Mr. Schoolcraft in 1822, and by Dr. Mantell in his 'Wonders of Geology.' The slab of limestone was taken from a rock which was exposed at the very margin of the Mississippi, opposite St. Louis, but only during very low water, such as does not happen more than once in ten years. It is a solid mass, upwards of a ton weight, of a purple and grayish tint, containing numerous shells, species of producta and pentromytes The impressions are so exactly like those of feet set upon a soft mud, that it is difficult to imagine that they can be a work of art; yet Dr. Owen thinks the difficulties of this hypothesis less than those of that which ascribes to them an existence before the limestone had hardened.

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* Bulletin de l'Académie de Médecine, Févr. 28, 1843.

† Oesterreichische Med. Jahrbucher, Oct. 1843. A summary of nearly all the observations on this subject is given by M. Rey, in the Revue Médicale, Oct. 1842.

‡ American Journal of Science and Arts, July, 1842.

The contents of the following papers have considerable interest, but are not of a kind which could be introduced into the Report:

Mr. Sibson's observations "On the relative positions of the thoracic and abdominal viscera," of which an abstract is given in the Lancet of August 12, 1843, and the Provincial Medical and Surgical Journal of the same date. Dr. Laycock's papers "In proof of the existence of a general law of periodicity in the phenomena of life," in the Lancet, October 22, &c., 1842. Mr. Ancell's "Commentaries on the works of Liebig," Lancet, November 13, &c., 1842. Papers by M. J. Parise in the Archives Générale de la Médecine, Juillet et Aôut, 1843, "On the apparent changes in the length of the lower extremities in changes of their position in regard to the pelvis." Numerous papers "On comparative and transcendental anatomy," by Dr. Knox, in the Medical Gazette. Dr. Willis's papers on the "Physiology of the skin and the lymphatics," in the Proceedings of the Royal Society March 9, 1843, and in the contemporary journals. Dr. Golding Bird's paper "On the microscopic globules found in urine," in the Guy's Hospital Reports. Mr. Gulliver's observations "On the frequency of fatty deposits in the degenerations of the tissues of old persons," in the Medico-Chirurgical Transactions, vol. xxvi. J. von Berres, Erfahrungen über die Zeugung, in the Oesterreichische Jahrbucher, April to September, 1843.

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